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EDITORIAL.

ITEMS AND NOVELTIES.

Alloys of Iron and Manganese.—The Terre-Noire Iron Company has recently taken out a patent in France for the preparation of alloys of iron with tungsten, titanium, silicon and manganese. The method which they employ for this purpose is the following:

Scrap iron and filings or turnings of cast or wrought iron or of steel, or even iron sponge coarsely pulverized, or any other iron or steel *debris*, in a more or less analogous state of division, is mixed with the minerals containing the tungsten, titanium, manganese, etc., or all of them together, or with quartz, these substances being all finely pulverized; the proportions in which the mixture is made determining the character of the alloy. The mass is then sprinkled, either with an ammoniacal solution or with a dilute acid, so as to moisten it completely and uniformly, and submitted to compression in a suitable mould. Considerable heat is evolved, and, at the end of a few hours, when the mould is opened, a very hard, compact mass is obtained, which may be broken, under the hammer, into fragments of any desired size. These fragments resist perfectly a red heat, and begin to crumble only when the cast iron they contain begins to melt. Treated in the ordinary way, in a suitable high furnace, they yield alloys of great value, the ferro-manganese containing from 25 to 50 per cent. of manganese, the ferro-silicon containing as high as 22 per

cent. of silicon. Ferro-tungsten and ferro-titanium, or even mixtures of all four together, may also be obtained in this way, but they require specially constructed furnaces, since the temperature at which they are obtained is so high that, to attain it, the blast must enter at a very high temperature and under a very great pressure. Moreover, under these conditions, especially in presence of the active base contained in the furnace-lining, the walls are very rapidly attacked, particularly in the lower portions. For this reason they have constructed their furnaces as follows:

The shaft is composed of refractory brick, as hard as possible, in which alumina predominates; the hearth is made of lime, of manganese, or of pure alumina, and the crucible is made of carbon, of lime, and of magnesia. This carbon crucible is formed in a single piece by moulding a mixture of pure graphite or of gas carbon or coke with coal tar in a strong sheet iron case. It is then heated in a close vessel to a dull red heat for several hours. A very hard, compact mass is obtained in this way, without cracks and without joints. The hearth is contained in a single case of iron plate, and is attached by dowels to the cast iron plate which holds the crucible. This crucible is movable, and is applied against the lower portion of the hearth, being retained by pressure; so that it may be changed at will. Beneath it is a foundation of masonry. This arrangement allows the renewing of the parts of the furnace most liable to wear, in a very short time. The blast is heated at least to 350° C., and enters under a pressure of from 13 to 15 centimetres (5 or 6 inches) of mercury.

It may increase the interest of this description to add some information concerning the experiments which have been made by the Terre-Noire Company, under the direction of M. Tessie du Motay, and the results which they have obtained.

It is well known that the use of manganiferous ores for the production of Bessemer pig irons, and especially for that of the spiegeleisen, which is run into the converter near the end of the Bessemer process, is indispensable in order to obtain those qualities of steel which are in demand for industrial uses, particularly for railroad purposes. Attempts have been made to avoid this necessity by introducing the manganese in fragments directly into the converter; but the pulverulent condition of the metal has always rendered its use in this way impracticable. By their success in preparing these solid cakes of ferro-manganese, containing a high percentage of manganese, the Terre-Noire Company have obtained a first result of very great value.

They have not confined themselves, however, to the results already attained. Seeking to extract from this first success everything of value which it contained, the inventors very naturally had in view the elimination of phosphorus, which has, until now, rendered it impossible to use in the high furnaces in which Bessemer pig iron is made, any ores which contain this substance, and which has prevented the use of old rails in the Siemens-Martin furnace. Employing the well-known purifying action of manganese, as well as of certain other reagents, to effect this elimination, they have not, indeed, succeeded in rendering it complete, a notable quantity of phosphorus being obstinately retained. But, at the same time, they have recognized the important fact that their products, containing now only traces of carbon and a maximum quantity of only four thousandths of phosphorus, possess all the qualities most desirable for the best steel rails; that is, homogeneity, elasticity, resistance to rupture, and especially resistance to compression. In a word, their products recall, but with all the superiority of steel to iron, the eminently good qualities of the iron rails made from the oolitic ores of Mazenay, d'Hayange, etc.

Almost complete decarburization, then, both of the Siemens-Martin and the Bessemer steels, permits the retention of an amount of phosphorus which, without this, would be entirely inadmissible; that is to say, these two metalloids, carbon and phosphorus, are incompatible with each other when both are present; but when either is present separately, an alloy is obtained having special properties, and which may be called carbon steel or phosphorus steel.

The slabs of ferro-manganese produced by the Terre-Noire Company are sold in the market at present at from 2½ to 3½ francs the kilogram (25 to 35 cents per pound). As it is necessary to add but two per cent. of it to the charge in order to obtain the remarkable results above given, some idea may be formed of the importance of this discovery.

Special ores being no longer necessary for the production of these steels, old products of inferior composition being now equally available, no doubt can arise that a vast field is opened by this discovery to iron masters, from which the railroad industry will derive important benefit. These results, too, it should be remembered, are not merely theory; they have been realized practically, and already large quantities of the new rails made in this way are in service on different French railways. We should note here, too, the remarkable

agreement of these results with those above mentioned as long ago observed, with iron rails made from phosphorus ores, an agreement practically confirmed by their use on railways.

Iron Mines in Algeria.—Iron mining in Algeria is daily taking a vastly increased importance. The ores are of excellent quality, and are already in great demand. The first mine opened, that of Ain-Mokhra, better known under the name of Mokta-el-Hadid, is developing an unlooked-for richness, the present production, although somewhat interfered with by the war, exceeding 30,000 tons a month. To transport the ore to Bône, where it is shipped, eight trains are run per day, each carrying 200 tons. England and the Netherlands are large purchasers of it, and it has already been shipped in considerable quantities to this country. Its price averages 27 francs per ton, the cost of transportation into France being 9 f. 50c. additional. In 1872, 366,614 tons were mined. In the first six months of 1873 the amount taken out was 220,000 tons. In the entire industry of this mine, including the mining proper, the railroad, the depot at Bône, and the shipping, 1542 workmen are employed, an increase of 378 over the number employed during the previous year. At a distance of 44 kilometers (27 miles) from Setif, on the old road from Bougie, called the Setif post route, occurs the important Djebel mine, and near Aïn-Rouah another very rich mine has been opened on the side of the mountain and well explored by means of shafts and galleries. The right to work this mine has been accorded by the Government to Nœvus, Nicolas & Company, and it is proposed to employ at once 800 miners. The ore will be shipped, at the port of Bougie, direct to all parts of the world.

Bauxite and the Aluminum Industry.—Bauxite, a mixed iron and aluminum hydrate, is the best ore of aluminum. It is found at several localities in France. That of Aubagne is not yet developed. That exported from Provence comes from the quarries of Cabasse, in the Department of Var, and those at the foot of the southern waterahed of the Alps in the arrondissement of Tarascon. These latter quarries, however, furnish products rich in iron, generally silicious, which are employed mostly for fixing the hearths of iron furnaces. The Cabasse mineral is quite free from silica, and is best suited for the manufacture of aluminum and its salts, and is also largely used for refractory fire bricks. The main uses of the Cabasse bauxite are:

1st. For the manufacture of chemical products; the works of Ludwigshafer, on the Rhine, using 1000 to 1200 tons of this mineral annually.

2d. For the manufacture of fire-bricks; M. Durschmidt, of Lyons, consuming it largely in making parts of the cylindrical furnaces of M. Siemens.

3d. For the production of artificial emery; certain varieties being worked into whetstones and sharpening stones, for various purposes demanding hardness and abrading power.

At the Luc station, the nearest point of shipment to Cabasse, the price of the bauxite is from 16 to 17 francs per ton.

The New Blake Hose.—A hose to meet the requirements of fire service must be eminently light, compact and impervious, as well as durable and easily kept in order. Leather hose is heavy and filthy, requiring constant oiling; while the demerits of the "four-ply" gum hose are its extreme bulk and weight, and its rapid decay. Unlined canvas hose is light and strong, but not impervious. Seamless rubber-lined hose does not admit of perfect union between the envelope and its lining. In order to meet this objection, the Blake hose is made by calendering pure gum *through* the pores of strong duck, then coating each side with pure rubber, sewing the fabric up and vulcanizing the whole together. Both rubber and duck are mildew-proofed. The new hose is light and strong, occupying little space, and is warranted for three years.

Hydropneumatic Pump for Transmitting Power.—At the February meeting of the Société d'Encouragement, M. Haton, in behalf of the Committee on the Mechanic Arts, made a report on a hydropneumatic pump, invented by M. Jarre, engineer and director of the Ornans Company. He says: "The problem of transmitting power to great distances is always one of great interest. But when the direction along which the power is to be transmitted from the motor to the point of application is crooked and beset with intervening obstacles, the transmission of motion itself is one of great difficulty, and is well nigh insoluble if we are limited to the employment of shafts of invariable dimensions. M. Jarre uses compressed air for transmitting the power of the motor, making it act directly upon water without the intervention of a piston. As the pressure in the air-tube, produced by the force pump placed at a distance from the water to be raised, varies but little, it is necessary to provide some

apparatus to render the effect of this pressure in the ejection cylinder an alternating one, so that this cylinder may be filled through an inlet valve and then emptied through a second valve opening outwards. This M. Jarre has accomplished by a sort of hydraulic cataract, based on the principle of the intermittent fountain, well known in physical cabinets. An oscillating balance beam alternately admits or shuts off the compressed air from the surface of the water to be raised, according to the variations in weight which take place in the two movable portions of the apparatus, either when immersed or when in the air; that is to say, when the water-level is raised or lowered. The action of the compressed air is made to follow very readily the motion of the water in the general operation of the machine, the pump continuing its action indefinitely so soon as the pressure of the moving air is sufficient.

Several pumps of the same general sort have been brought into use within the last two or three years. There is a certain disadvantage, without doubt, in having the air act upon the liquid directly, because the useful portion of the pressure given by the compression apparatus is in this way limited to the fixed pressure of the ascending column of liquid and the loss by the tube. But this inconvenience is compensated by certain special advantages, which make this apparatus of great value in certain cases. For example, one of these pumps is placed 150 metres (500 feet) from the motor, the compressed air being conducted to it by a tube 0·02 metres ($\frac{3}{4}$ inch) only in diameter, having in this distance twenty-four bends at right angles. The water raised, which is 75 litres (16$\frac{1}{2}$ gallons) per minute, issues from a tube 0·04 metre (1$\frac{1}{2}$ inches) in diameter, having nine bends at right angles in its course, and narrowed also by two cocks. It is difficult to conceive of a method by which, under these conditions, motion could be transmitted to such a distance by means of metallic shafting. Moreover, the hydraulic mechanism, since it requires no attention, and is liable to no accident, will undoubtedly, under many circumstances, have a decided preference over the ordinary pumps for raising water.

The Committee on the Mechanic Arts return their thanks to M. Jarre for his interesting communication made to the Society, and recommend the insertion of this Report in the Bulletin, together with a drawing of the machine.

Strength of Riveted Joints.—In consequence of the results obtained in an extended series of experiments made by Mr. Fairbairn,

relative to the resistance of bolts or rivets when used to unite together metallic plates, he asserts:

1st. That joints made with drilled holes are weaker, and elongate less before rupture, than those made by the use of punched holes.

2d. That hand-riveted joints are somewhat more resistant than joints riveted by machinery.

3d. That the resistance of the rivets to rupture is considerably increased if the edges of the holes are first rounded, so as to diminish their cutting action.

Artificial Coloration of Wine.—In a note communicated to the Pharmaceutical Society of Bordeaux, at a recent meeting, M. Carles give some of the methods which he has employed for the detection of artificial coloring matters in wine. Among the various substances used for this purpose, the author enumerates hollyhocks, cochineal in ammonia, myrtle berries, and aniline red. Regarding the methods of analysis thus far in use defective as well as somewhat difficult of execution, M. Carles proposes a new and simple method, which is at the same time exact and easily available; it is based on the changes of color which artificially colored wines undergo when subjected to the influence of a large quantity of water, of an excess of gelatin, or, better, white of egg, or ammonia. All pure wines preserve their color when mixed with 100 to 150 times their volume of water; they become slightly green by the action of ammonia and are decolorized by agitation with an excess of albumen. These reactions are very sharp when they are obtained in a deep vessel with a white bottom, like a coffee cup, for example; they are often sufficient for the detection of a foreign coloring matter. Other and special tests are applied to prove the presence of individual colors, as that of phytolacca, elderberry, hollyhock, myrtleberry, cochineal in ammonia, etc. The following is the method of procedure:

The suspected wine is mixed with water in the proportion of two to five parts of wine to 250 parts of water. Two cases then arise:

1st. *The wine preserves its color or turns violet.* If now it is for the most part decolorized by albumen, and is turned decidedly green by ammonia, it is pure.

If it is turned yellow by ammonia, phytolacca.

" " " blue " " cochineal.

" " decolorized by ammonia and by acids, rosaniline.

2d. *It becomes green before, or better after, fining.* Then (1) if it

becomes violet on adding aluminum acetate, and gives a red precipitate with basic lead acetate, the color is due to elderberry. If the basic lead acetate gives a bluish-green precipitate, the color is due to hollyhock. (2) If it be turned green by aluminum acetate, myrtleberry gives the color.

When dealers in and manufacturers of wine improve the color of their products by adding fuchsine, a salt of rosaniline, they commit not simply a fraud, but also an attempt upon the health of the consumer. The toxical properties of this substance has been long ago proved by decisive experiments. It cannot but be of use, therefore, to the community to devise processes by which the presence of fuchsine in a vinous liquid may be detected. To the test for this substance we have given above, we add the following: Fifty grams (1½ ounces) of the wine is introduced into a white glass bottle, whose capacity is 120 to 130 cubic centimetres (four ounces) and treated first with 20 grams basic lead acetate and then with the same quantity of amyl alcohol. If now, after vigorous agitation, the liquid appears colorless, this is proof that the wine was not colored by fuchsine. But if, on the contrary, it possesses a red tint, this is proof that the wine has received color from this poisonous substance. This test is based on the fact, 1st, that the coloring matter of pure wine is precipitable by basic lead acetate, while fuchsine is not thrown down by this reagent. And, 2d, that amyl alcohol, which dissolves both when they are free, has no longer any action on œnoline when combined with lead, while it still retains the power of removing fuchsine from the liquid.

Valuation of Commercial Indigoes.—M. Henry Bergé, Professor of Applied Chemistry in the University of Brussels and chemist to the city, has recently published a report on the valuation of indigoes, especially of those obtained by the new Sayers process. He says: The new process of Joseph Sayers, for extracting the coloring matter from the indigo-plant, is a wonderful step in advance of previous methods. Without taking into the account the rapidity and the almost mathematical precision of this method—without considering the considerably greater yield which is given by it—it is sufficient to compare the analyses of the indigoes prepared by the Sayers method with those of the ordinary commercial indigoes, in order to prove the enormous superiority in quality of the former over the latter.

I have made comparative analyses of twenty-four specimens of in-

digo, of which ten were of various origins and fourteen were extracted by the Sayers process. The ten commercial samples were delivered to me by M. Schalknyck, an indigo broker in Rotterdam, and included six specimens of Java indigo, two of Bengal indigo and two of Manilla indigo. The following table gives the marks, the prices and the composition of these several indigoes:

District and Marks.		Blue coloring matter, or indigotin.	Mineral matters or ash.
Java Indigo, SK	75 centimes.	57·19	14·28
" " ABCD	125—	27·28	44.47
" " KP	225—	55·13	9·02
" " GWG	460—	68·68	5·09
" " WJF	550—	69·82	2·18
" " CFE	600—	75·78	2·69
Bengal Indigo,	450—	72·17	2·93
" "	525—	75·36	1·99
Manilla Indigo,	60—	14·47	45·63
" "	125	24·55	37·98
Sayers Java Indigo,	No. 1	69·37	2·31
" " "	" 2	72·35	2·82
" " "	" 3	74·03	2·59
" " "	" 4	69·32	3·48
" " "	" 5	66·98	4·25
" " "	" 6	65·38	3·95
" " "	" 7	69·63	2·89
" " "	" 8	71·20	1·53
" " "	" 9	71·40	2·36
" " "	" 10	74·53	1·61
" " "	" 11	71·11	2·14
" " "	" 12	67·89	2·76
" " "	" 13	67·85	2·66
" " "	" 14	76·70	2·50

A special characteristic of the indigoes extracted by the method of M. Sayers is the very small quantity of mineral matters or ash which they contain; thus, for example, the mean results of the above analyses of the ten samples of ordinary commercial indigo is 16·62 per cent. of ash; while the average content of ash in the Sayers specimens is only 2·77 per cent.—a difference in favor of the latter of 13·85 per cent. Moreover, the richness in indigotin is very remarkable in the Sayers samples; the yield is 70·58 per cent. as a mean;

and it never descends below sixty-five or sixty-six per cent. Bengal indigo, coppery, good ordinary, contains as a mean only 61·4 per cent. Sometimes very fine Bengal or Java indigoes are obtained which contain as high as seventy-five and even eighty per cent. of indigotin; but these are exceptional products. The market affords, it is assumed, ten per cent. of good indigo, thirty-five per cent. of average quality, and fifty-five per cent. of ordinary indigo. Of course, we are now speaking of good, genuine, merchantable indigoes, and not those subsequently treated or falsified.

From these facts, it appears that not ten per cent. of the indigoes of commerce contain more than from sixty five to sixty-six per cent. of indigotin; but this is the minimum proportion yielded by the Sayers process of extraction. The importance of this method, then, in the preparation of a substance as high in price and as extensively used as indigo, is sufficiently obvious from these analyses, guaranteed, as they are, by the reputation of M. Bergé.

Editorial Correspondence.

INCREASE OF RESISTING POWER OF METALS UNDER STRESS.—[In the March number of this Journal, reference was made to a memorandum by Commander Beardslee, relating to certain experiments made by this gentleman upon some specimens of old chain iron, the results of which confirmed the recent novel discovery announced by Prof. R. H. Thurston, that metals left under stress during periods ranging from one to several days really gained in power of resistance. We have recently received the accompanying statement, prepared by Com. Beardslee in continuation of the subject, which furnishes a most conclusive confirmation of the discovery of Prof. Thurston.—ED.]

Editor of Journal of Franklin Institute:

DEAR SIR,—I send you herewith the results of a series of experiments which I have collated while engaged in testing some old chain iron on hand. The machine in which the tests were made is the "Dynamometer" belonging to the Ordnance Department. The iron was generally of a low grade of tensile strength. The test specimens

Experiments to Determine the Limit of Tensile Str

Table No. 1.

No.	Limit of Elasticity. 1st strain.	Hours intervening	2d strain	Increase.	Increase per cent	Increase per sq. inch.	Length. Before	Length. After.	Diameter. Before.	Diameter. After.	
	lbs.		lbs.	lbs.		lbs.	inches.	inches.	inch.	inch.	
1	24·300	in 17	28·250	3·950	16·	7·900	$2\frac{9}{16}$		$\frac{1}{16}$		Bloom hammered, from
2	24·900	out 16	28·550	3·650	14·6	7·300	$2\frac{9}{16}$		$\frac{1}{16}$		Old boilers and mixed s
3	23·900	in 16	29·000	4·000	16·7	8·000	$2\frac{9}{16}$		$\frac{1}{16}$		Same bloom.
4	25·100	in 16	27·000	1·900	7·6	3·800	.2	$2\frac{6}{16}$	$\frac{1}{16}$	$\frac{10}{16}$	Turned from $1\frac{3}{4}$ inch ch
5	25·800						2	$2\frac{6}{16}$	$\frac{1}{16}$	$\frac{10}{16}$	Piece from same link.
6	24·050	out 16	27·200	3·150	13·1	6·300	$1\frac{14}{16}$	$2\frac{6}{16}$	$\frac{1}{16}$	$\frac{11}{16}$	Turned from $1\frac{3}{8}$ chain
7	24·075	in 16	27·750	3·675	15·3	7·350	$1\frac{14}{16}$	$2\frac{9}{16}$	$\frac{1}{16}$	$\frac{11}{16}$	Same link.
8	25·125	in 16	26·600	1·475	5·9	2·950	2	$2\frac{5}{16}$	$\frac{1}{16}$	$\frac{11}{16}$	Turned from $1\frac{15}{16}$ inch c
9	25·350	out 16	27 650	2 300	9·	4·600	2	$2\frac{5}{16}$	$\frac{1}{16}$	$\frac{11}{16}$	Same link.
10	24·800	in 16	26·450	1·650	6·7	3·300	2	$2\frac{2}{16}$	$\frac{1}{16}$	$\frac{11}{16}$	Turned from 2 inch cha
11	25·600	out 16	26·450	·850	3·4	1·700	2	$2\frac{2}{16}$	$\frac{1}{16}$	$\frac{11}{16}$	Same link.
12	14·700	out 16	16·125	1·425	9·7	5·700	$1\frac{9}{16}$	$1\frac{15}{16}$	$\frac{9}{16}$	$\frac{7}{16}$	Turned fr m $1\frac{1}{2}$ inch ch
13	14·750	in 16	16·450	1 700	11·5	6 800	$1\frac{9}{16}$	$1\frac{15}{16}$	$\frac{9}{16}$	$\frac{7}{16}$	Same link
14	13·000	in 16	14·800	1·800	13·8	7·200	$1\frac{9}{16}$		$\frac{9}{16}$		Turned from $1\frac{5}{16}$ inch c
15	13·200	out 16	14·175	·975	7·4	3·900			$\frac{9}{16}$		Same link.
16	14 100	out 40	15·150	1·050	7 4	4·200	$1\frac{9}{16}$	$2\frac{1}{16}$	$\frac{9}{16}$	$\frac{7}{16}$	Turned from $1\frac{1}{16}$ inch c
17	13 600	in 40	15·400	2·300	16 9	9·200	$1\frac{9}{16}$	2	$\frac{9}{16}$	$\frac{8}{16}$	Same link.
18	14·350	in 16	16 050	1·700	11·1	6 800	$1\frac{9}{16}$	$2\frac{1}{16}$	$\frac{9}{16}$	$\frac{7}{16}$	Turned from 1 inch cha
19	14·500						$1\frac{3}{4}$	$2\frac{5}{16}$	$\frac{9}{16}$	$\frac{7}{16}$	Broke first strain.

Nos. 8, 9, 10 and 11 of above table were subjected to further strains, until finally broken, with resu

Table No 2.

No.	1st strain.	Interval.	2d strain.	Difference.	Per cent.	Interval.	3d strain.	Difference.	Per cent.	Interval.	4th strain.	Difference.	Per cent.	Interval.	5th strain.
	lbs.	hours.	lbs.	lbs.		hours.	lbs.	lbs.		hours	lbs.	lbs.		hours.	lb
8	25·125	in 16	26·600	+1·475	5·9	in 7	27·350	+ ·750	2·7	in 41	27·250	− ·100	3·	in 7	27·
9	25·350	out 16	27·650	+2·300	9·	out 7	26·575	−1·075	4·	out 41	28·300	+1·725	6·1	out 7	27·
10	24·800	in 16	26·450	+1·650	6·7	in 8	25·500	− ·950	3·7	in 16	27·400	+1·900	6·9	in 4	26·
11	25·600	out 16	26·450	+ ·850	3·4	out 8	27·450	+1·000	3·6	out 16	26·375	−1·075	4·1	out 4	25·

RMINE THE LIMIT OF TENSILE STRENGTH OF IRON.

TABLE No. 1.

ımeter.		Remarks.
e.	After.	
.	inch.	
		Bloom hammered, from old boiler plate
		Old boilers and mixed scrap.
		Same bloom.
	$\frac{10}{16}$	Turned from $1\frac{3}{4}$ inch chain iron. Fibrous.
	$\frac{10}{16}$	Piece from same link. Broke on first strain.
	$\frac{11}{16}$	Turned from $1\frac{3}{16}$ chain iron. Fibrous.
	$\frac{11}{16}$	Same link.
	$\frac{11}{16}$	Turned from $1\frac{5}{16}$ inch chain iron. Coarse and granulous.
	$\frac{11}{16}$	Same link.
	$\frac{11}{16}$	Turned from 2 inch chain iron. Granulous.
	$\frac{11}{16}$	Same link.
	$\frac{7}{16}$	Turned fr m $1\frac{1}{4}$ inch chain iron. Fibre dark and coarse.
	$\frac{7}{16}$	Same link
		Turned from $1\frac{5}{16}$ inch chain iron. Fibre foundry cast and granulous.
		Same link.
	$\frac{7}{16}$	Turned from $1\frac{1}{16}$ inch chain iron. Close fibre.
	$\frac{8}{16}$	Same link.
	$\frac{7}{16}$	Turned from 1 inch chain iron.
	$\frac{7}{16}$	Broke first strain.

ains, until finally broken, with results as follows:

TABLE No 2.

	4th strain.	Difference.	Per cent.	Interval.	5th strain.	Difference.	Per cent.	Breaking strain.	Lever balanced after 1st strain.	2d strain.	3d strain.	4th
ırs	lbs.	lbs.		hours.	lbs.	lbs.		lbs.	lbs.	lbs.	lbs	
41	27·250	− ·100	3·	in 7	27·000	− ·250	·9		24·150	25·550	25·100	
41	28·300	+1·725	6·1	out 7	27·000	−1·300	4·6		24·300	26·700	25 875	
16	27·400	+1·900	6·9	in 4	26·500	− ·900	3·4	23·475	23·950	25·125	24 500	2
16	26·375	−1·075	4·1	out 4	25·875	− ·500	1·9	22 850	24·70	25·625	25 600	2

Items, Plate IV.

ed a'ter	
strain.	4th strain
lbs	lbs.
5·100	
5 875	
4 500	25·950
5 600	25·600

were prepared by turning down pieces 3¾ inches long, leaving a cylinder of 2 inches in length and $1\frac{3}{16}$ (nearly) in diameter, for a section equal to ½ square inch area, and to $1\frac{9}{16}$ in length, $\frac{9}{16}$ in diameter (nearly) for a section of ¼ square inch area. A head was left at each end for the purpose of clamping in the machine.

The crank was turned at a uniform rate of about 32 revolutions per minute; the amount of strain was indicated upon a lever, which constantly rose as in an ordinary beam scale. When the "limit of elasticity" is reached, the lever ceases to rise, and falls; if then the strain be increased there will be no corresponding rise to the lever, but the sample will presently break. At the instant the lever ceases to rise the amount of strain is noted and recorded. At this point the weights in each case were taken from the lever until it balanced; the following were the deductions:

On the chain iron, ½ square in. area, 780, 875, 900, 800, 800, 875, 850, 900 lbs.; average, 857 lbs.

On chain iron, ¼ sq. in. area, 550, 625, 675, 750, 550, 600, 600 lbs.; average, 612 lbs.

On the scrap iron of ½ sq. in. area, 1050 lbs. and 1225 lbs.

The pieces were generally tested in pairs, one piece being taken from the machine when the limit of elasticity was reached, and the other left under stress for the same period, generally from 3 P.M. till 7 A.M. next day, when both were broken. In each case the falling of the lever at the first strain was slow, and it required close attention to mark accurately. In the succeeding strains the lever would drop suddenly.

An analysis of Table 1 shows that the percentage of gain between first and second strains was as follows:

Six tests, ½ sq. in. area, left under stress, increased 16 p. c., 16·7 p. c., 7·6 p. c., 15·3 p. c., 5·9 p. c., 6·7 p. c., or, on an average, 11·3 p. c. (nearly).

Four tests, ½ sq. in. area, left without strain, increased 14·6 p. c., 13·1 p. c., 9 p. c., 3·4 p. c., or, on an average, 10 per cent.

Leaving out No. 11, which seems an extreme, the average would be 12·2 per cent.

Four tests, ¼ sq. inch area, left under strain, increased 11·5 p. c., 13·8 p. c., 16·9 p. c. and 11·1 p. c., or an average of 13·4 p. c.

Three tests, ¼ sq. in. area, taken out from the machine, increased 9·7 p. c., 7·4 p. c. and 7·4 p. c., an average of 8·2 p. c. (nearly).

The average per cent. increase in all the tests is 10·8 per cent. on the figures of the first strains.

After the second pull, it was considered that the specimens had no more life, and they were broken by a few more turns of the crank, the lever being down and making no response.

The Commandant suggested a continuation of the strains, and Nos. 8, 9, 10 and 11 were pulled, at intervals, until broken, as per Table 2.

In making this second series it was noticeable that the greater portion of the increase in length, and contraction of diameter, occurred at the first pull, very slight changes taking place on after pulls until the fifth strain, when, before breaking, they stretched, and diminished nearly $\frac{1}{8}$ and $\frac{1}{16}$ of an inch.

These experiments having been carried on in connection with other duty, have not the value that a series of more careful ones would have, in which the iron should be uniform, and the temperature and other conditions noted. They, nevertheless, point to a curious result, evidently not that of accident.

Very respectfully,

L. W. BEARDSLEE, *Commander, U. S. N.*

Washington, April 8, 1874.

Editor of Journal of Franklin Institute:

DEAR SIR,—Since writing the article on the use of the polar planimeter in the calculation of earth work and for other purposes, which appeared in the last number of your "Journal," I have had occasion to use the planimeter in the ordinary course of my business. I am convinced of its value as a regular office instrument, and, willing to aid in its introduction generally among engineers and others, have made arrangements with Messrs. Buff & Berger, astronomical and surveying instrument makers, of this city (9 Province court), by which they are enabled to receive orders for polar planimeters, to be graduated under my personal supervision, and each instrument to be accompanied by plain and concise directions for its use; the graduation and the directions to be drawn, moreover, with reference to the special wants of each customer.

Yours very truly,

CLEMENS HERSCHEL, *Civil Engineer.*

Boston, April 11, 1874.

Civil and Mechanical Engineering.

IMPROVEMENT OF THE OHIO RIVER.*

By Felix R. Brunot, of Pittsburgh.

The improvement of river navigation is of greater national importance in the United States than in any of the Old World countries. Our magnificent distances, the wide dispersion of heavy wealth-creating elements, such as coal, ores and lumber, the often long distances between the points of origin and consumption of both these and the products of the soil, and the great length and adaptability of our rivers to the purposes of cheap transportation, should make the subject of their improvement, to the highest degree of their capability, one of transcendent interest.

That such a stream as the Ohio, susceptible of being made to convey the traffic of a hundred railroads throughout its length of nearly a thousand miles, by the expenditure of a sum less than the cost of a single railroad from Philadelphia to Pittsburgh, should be suffered to remain in its natural condition, is, to say the least, discreditable to the nation.

Congress, claiming, as it does, the entire control of the stream, is chiefly responsible for the fact that the Ohio still remains useless for a large portion of the year. Let Congress but consent to give up its control for the purpose of improvement, and many men could be found, any one of whom would undertake to raise, by the ordinary methods of public enterprises, the sum necessary to convert the Ohio, from its source to its mouth, into a perennially navigable river. Few would desire that the Ohio, or that other great heritage and highway of the nation—the Mississippi—should ever become the property of a private corporation; certainly the writer is not among the number. The thought is only introduced to set forth in a stronger light the apathy of the Government in permitting so great an element of economy and wealth to remain so long unavailable. Again and again the grand statistics of the existing commerce of the great rivers have been laid before Congress, with the only petty results of a few thou-

* "*Radical Improvement of the Ohio River.*" *Report of* G. Weitzel, *Major of Engineers, Brevet Major-General U. S. A., and* W. E. Merrill, *Major of Engineers and Brevet Colonel, to* Gen. A. A. Humphreys, *Chief of Engineers, U. S. A.* Congressional Document, Feb. 12th, 1874.

sands of dollars spasmodically appropriated to "remove snags" or "complete wing-dams;" and again and again the process has been repeated, until the task of raising Congress to a reasonable estimate of the national importance of the subject has hitherto seemed to the patient millions of the Ohio and Mississippi Valleys well nigh hopeless.

The report of Gen. Weitzel and Col. Merrill puts a new aspect on the affair, and in connection with the present demonstration of the agricultural, industrial and commercial interests of the country in favor of cheap transportation, it is difficult to see how the present Congress can fail to take the preliminary steps towards a radical improvement of both the Ohio River and the Upper Mississippi, from St. Paul to St. Louis.

Messrs. Weitzel and Merrill were, by appointment of the War Department, constituted a Board to examine certain proposed plans, and after mature consideration of the capabilities of the river and the requirements of its trade, to recommend, if possible, some system for the radical improvement of the Ohio. The results of a year of intelligent and laborious investigation and experiment by the Board are set forth in their report, which has lately been published by Congress, and is a document of ninety-six Congressional pages.

The Board, in the beginning of their report, after stating the object of their appointment, and referring to their preliminary report of May 1, 1872, remark :—

"As this report did not reach Congress, no appropriation was made. Since then the Board has been actively engaged in studying the history of similar works in this country and abroad, and in testing, by large models, all the various plans that appeared likely to answer the purpose. *They are now fully prepared to submit a plan which they feel confident will fully meet the necessities of the case.*"

A brief reference to some of the old methods and propositions for the improvement of river navigation may aid in reaching a correct appreciation of the importance of this announcement.

Ancient and Modern Methods.

All rivers, except the short and comparatively small streams which are supplied from springs or perpetually melting snows in summer, are subject to great variations in the quantity of water flow. Many of them, of considerable size and navigable for a part of the year, could be made navigable at all times were it possible to hold back the

flood water and supply it day by day, as required, through a channel reduced in area by artificial means. This plan of reservoirs and channel, either natural or artificial, has been used for time immemorial for purposes of irrigation or canal navigation.

Mr. Telford, sixty years ago, proposed to improve the navigation of the river Severn by making reservoirs among the hills of Montgomeryshire, which he claimed would also serve to regulate the floods of the stream; but Rennie, another noted English engineer, condemned the plan as "ridiculous."

Mr. Chas. Ellet, a distinguished engineer, became imbued with a similar idea in regard to the Ohio River, and expended much time in an able attempt to demonstrate its feasibility.

Mr. W. Milnor Roberts, C. E., has shown conclusively that, owing to the magnitude of the stream, its extraordinary floods, the rapid descent and flow of its originating tributaries, the impossibility to find reservoir sites available to collect and retain a sufficient quantity of the rain fall, and for other reasons, the plan as proposed is impracticable. That reservoirs may be found useful adjuncts to whatever system of improvement may be adopted is, however, agreed upon by Mr. Roberts and all the engineers who have written upon the subject.

Opinion of Henry Clay.

When Mr. Ellet's plan was under discussion in the United States Senate on a proposition to appropriate money for surveys, it was advocated by Mr. Clay, who said that "for less money than the cost of a custom-house in New York or Boston, we may effect an object for which I contend that if *twenty millions* were applied, and the object could be accomplished with that amount of money, *it would be a profitable, just and national appropriation of the public funds.*"

This remark of that eminent statesman indicated what his convictions were as to the duty and correct policy of the Government, and atones for his oft-quoted slur upon the noble river, which, he said, was "frozen up half the year and dry the other half."

Where rivers have a gentle and uniform flow, and a broad bed, it is manifest that when the supply of water decreases so as to render them too shallow for navigation, some degree of improvement may be made by contracting the width of channel. For instance, if the water flow is 200 feet wide and one foot deep, by contracting it to one-half of the width you will have substantially a flow of one hundred feet wide and two feet deep. If this contraction were made by

actually building out the banks for the whole length of the stream, or, to use a word coined by English engineers, *canalizing* it, the difficulty is created that in floods the water-way would be insufficient, and the stream must necessarily overflow its banks.

To narrow the channel and yet avoid the overflow, the system of *jetties*, or, as the French call them, *barrages*, was adopted. The jetties are weirs, or dams, projecting from the shore of each side of the stream to the required distance, so as to throw all the water into a contracted channel. They are generally of rough stones or boulders, and low enough to be beneath the surface of the water at moderate stages, and are usually not in pairs opposite to each other, but alternating.

Seven hundred years ago this system was used in Egypt to check the rapidity of streams and improve their navigation. The jetties were made opposite to each other, and the passage in low water was narrowed or stopped by planks, which were removed for the passage of boats, and replaced as required. It is known also that more than 300 years ago the Chinese had a similar arrangement upon their rivers, and that they have it yet.

Mr. Robert Fulton, in his treatise on River Navigation, speaks of a like system in Flanders at a very early day.

In all parts of the civilized world great improvements have been made upon this primitive plan; yet, strange to say, it is substantially the system which has been pursued up to this time upon the Ohio River. The United States Government—ahead of all the world in so many things—is, so far as the improvement of the Ohio navigation is concerned, about 700 years behind all the civilized countries of Europe.

A single paragraph in the report of the U. S. Engineers demonstrates the utter inadequacy of the system of jetties, or, as we call them, wing dams, for the proper improvement of the Ohio River. Speaking of White's ripple and the Trap, 11 miles below Pittsburgh, they say, "Here the whole body of water passes through a space whose width at low water is 230 feet, and yet at that stage the depth for navigation is frequently but 12 inches."

Herman Haupt, Esq., Civil Engineer, proposed, in 1855, an improvement of the system, which consisted substantially in the *canalization* of the river, the proposed open channel to be 200 feet wide. It is evident from the above quotation that such a channel would give no satisfactory result.

W. Milnor Roberts, C. E., published an able and important paper in the "Journal of the Franklin Institute," in 1857, proposing the system of "Locks and dams with sluice-ways or chutes for descending navigation." Subsequently, Mr. Roberts, when in charge of the Ohio River improvement, advocated the same system, with the addition of adjustable gates or dams to close the sluices in low water, and which he deemed practicable.

Gen. Weitzel and Maj. Merril have been led by their investigations to conclusions which may best be given in the language of their report. They say:

"In the Upper Ohio by far the most important navigation is the transport of coal. Pittsburgh annually ships over 50 million bushels to points below, and all the large cities from Cincinnati to New Orleans receive their principal supplies from this source and in this way. Under existing arrangements all this coal comes out on floods of 7 feet or more, a single steamboat bringing down from eight to twenty barges. The representatives of this interest, although not content with the river as it is, would prefer no change unless it were of such a character that they would have no more delay or trouble in getting their fleets down the river than they have now. Coal fleets are so large and ponderous that they require a wide river for manœuvering; and, besides, the barges must be bound together in every direction in the firmest possible manner by cables and screw-clamps. It is very tedious and difficult to make up a coal fleet, and somewhat hazardous; and it is almost indispensable when the boats are once firmly connected they should remain so until the whole fleet is landed at its destination. For this reason the passage of a lock after the fleet has started is most objectionable, and would cause insupportable delay and danger. The coal interest of Pittsburgh is therefore a unit in opposing the erection of any dam in the Ohio River unless some modification can be introduced into the ordinary slack-water system that will permit the passage of fleets without requiring them to be broken up and re-formed below the dams.

* * * * * * * * It may, therefore, be considered as settled that the adoption of the system of locks and dams on the Ohio River is dependent upon the practicability of making an opening in each dam of sufficient width to pass a coal fleet without any delay, of constructing a movable hydraulic gate to open or close this opening at will, and of building a chute or inclined plane of such length and shape that there will not be an excessive velocity in it nor any objectionable wave at its entrance or its exit.

"The average width of a coal fleet is 125 feet. The least width of chute that can now, in advance of experience, be assumed as necessary is 200 feet. The first question, therefore, is, can a gate be constructed that can be made to close or open this passage at will?"

When we consider the volume and force of a body of water 200 feet wide, and from 3 to 10 feet deep, rushing on with a velocity of

four or five miles an hour, to be stopped or set free at will by a gate which must present no obstacle in itself or the machinery for working it, either above or below the water, to obstruct the passage of boats, or be liable to damage from ice or freshets, the desideratum may well seem impracticable; how ponderous and strong the gate must be to resist the weight and surge of water; what power or machinery can handle the massive structure?

A similar problem in regard to their own rivers has engaged the attention of the most distinguished French and English engineers for 30 years, with progressive success, and there are now in daily use upon their rivers more than a dozen plans, all of which are found to be improvements on the obsolete jetty system.

Following the passage already quoted, Messrs. Weitzel and Merrill remark:

"The following extracts from Hagen and Becker, two of the most prominent writers on hydraulics, will show what has thus far been done in this country and in Europe in cases similar to the one with which we have to deal. After discussing generally the uses of the movable dams and their importance, Hagen proceeds to enumerate the different plans which have been suggested, prefacing it with the remark that no one seems yet to furnish a full solution of the problem. He then says: 'A complete solution of the problem seems to require that the pressure of the water, whether standing or flowing, should furnish the power by which the dam is erected or removed. Or, again, the construction must be such that, notwithstanding the requisite solidity of the structure, it can be managed with a slight power, for which only a few men and short time are required.'"

Exemplification of the French System.

The report then proceeds to collate from the above-named authorities, and other sources, accurate descriptions of thirteen or more of the best systems in use upon European rivers.

The following is an abbreviated description of some of the works being executed by the French Government. It is cited in the report from the "Annales des Ponts et Chaussées"

"The great water route connecting Havre, Rouen and Paris with Lyons and Marseilles, by the Seine and Yonne rivers, the Burgundy Canal and the rivers Saone and Rhone (see map on plate 6), had, until September, 1871, a very defective section; in fact, a veritable gap, 118 miles long, between Paris and Laroche, where the Burgundy Canal enters the Yonne. In fact, for eight or nine months in the year, from March to November, the descent of loaded boats was only possible, especially on the Yonne, twice a week, by the aid of artificial floods or waves from the upper Yonne, and the draught of water available varied from 2½ feet to 3 feet four inches, and 3 feet 7 inches at most; so that

boats from the Burgundy Canal, drawing from 3 feet 7 inches to 4 feet 7 inches, were obliged to break bulk at Laroche. As to ascending craft, they were generally empty, or only carried a few tons of merchandise. This costly, slow, and altogether insufficient navigation, was accompanied by great fatigue, by danger, and by numerous accidents. Although it was somewhat less difficult on the Seine, navigation was much hindered, and often stopped, between Montereau and Paris. Since the 1st of September, 1871, there has been a continuous navigation between Paris and Laroche, thanks to 17 movable dams constructed on the Yonne, and to 2 cut-offs and 12 movable dams constructed on the Seine. The minimum depth of water in the pools is 5 feet 3 inches, and therefore boats can move up and down with perfect safety, drawing from 4 to 5 feet. At present, while the works are yet incomplete, the greatest part of the loads, especially those that come from the Nivernais Canal, do not draw over 4 feet; but when the works of the same kind (that is, 8 movable dams and one cut-off, now being built between Laroche and Auxerre, where the Nivernais Canal enters) are finished, which will be by the end of this year (1873), the great advantages will be happily realized which the government had in view, and which were looked for with impatience, but with confidence, by the boating, commercial, industrial and agricultural interests.

* * * * * * * * * * *

"The works for improving the navigation between Montereau and Laroche, authorized in 1861, were nearly completed in 1868, when a continuation up the Yonne to Auxerre was ordered. These new works were commenced in 1869, and although retarded by the war with Germany, will probably be completed by the end of the present year. These new works consist of eight movable dams (of which seven have locks), one cut-off, dredging, bank-protection and minor works. The dam of La Chainette, just below Auxerre, has a navigation-pass 138 feet wide, closed by a Poirée needle-dam and a permanent weir 656 feet long, whose top is even with the surface of the post. The sole of the navigation-pass is 20 inches below low water. The chamber of the lock attached to the dam is 27 feet wide, and has an available length of 305 feet. This dam was built under the old system of creating temporary floods. The seven new dams have navigation-passes varying in width from 98 to 115 feet, closed by Chanoine wickets, with their soles 2 feet below low water. The weirs, whose soles are 20 inches above low water, are from 82 to 131 feet in length. Six of these weirs have needle-dams on the Poirée system, and one has large Girard shutters 11½ feet wide, with a vertical height of 6½ feet."

The navigation-passes on the upper Seine and Yonne are from 98 to 211 feet in width, according to circumstances and locality.

The low water discharge on the upper part of the Yonne is 459 cubic feet per second, and the average slope of the stream is 3½ feet per mile, and on the lower part the flow is 600 cubic feet per second, and the slope 1 foot 10 inches per mile.

Let us compare the capacity out of which this navigation has been created with that of the Ohio. The low water discharge of the Ohio at Wheeling, with only 1 foot of water on the bar, is 1700 cubic feet

per second. The average slope between Pittsburgh and Wheeling is about 10 inches per mile, and between Wheeling and Cincinnati only 6¾ inches per mile.

The fact here apparent, that the Ohio, in its exceptionally lowest stage, has four times as much water as the Yonne, and only one fourth as much fall per mile, indicates sufficiently its superior capability of improvement, and to a much greater extent than the French river, which I have chosen at random, from many others, for the illustration.

And what is true of the Ohio in this respect is equally true of the upper Missisippi from St. Paul to St. Louis.

The French devices for closing and opening the navigation passes or chutes, are many of them very ingenious and very complicated. The best in use seems to be the Chanoine system, so called from its inventor.

The following description of one of the movable dams on the upper Seine and Marne, taken from the *London Engineer* of October 22d, 1867, is rather more in detail than that of the report:

"Fig. 1, Pl. I, shows in section, in line of the stream, the navigable channel of one of the twelve *barrages* of the upper Seine, which have been constructed between Paris and Montereau, each with lock pits of twelve metres wide by 180 metres long in the clear. The river banks above and below are pitch-paved, at a slope of 45 deg., a navigable pass of from 40 to 55 metres wide—one only, at Melun, being 65 metres—and a regulating weir of from 60 to 70 metres long. Each navigable pass has from 30 to 42 panels to close it, each being three metres high by 1·20 metres wide, and with a narrow space of 0·10 metres between the vertical edges of each. The other chief dimensions may be had from the figure, which is to scale. The figure shows the application of the flat-bottomed gabbard, which is employed to raise again the *hausses* into place when the waters have fallen too low for navigation but by lockage. During the period of free navigation the panels are flat down on the bottom, in the position marked by the word "open," the gabbard being moored on the up-stream side, and so that at the curves of its bows it clears the tail end of each panel, the first of three or four of these having been got up into place from the wing-wall or pier, and these being then used by the aid of the crutches seen between the gabbard and the *hausse* as fulcra to keep off the former; the tail end of each panel in succession is seized by a hooked iron rod, and it is dragged up into the position marked in dotted lines as "partly open." The heavy *cast iron* jointed spur-brace, with the handle-like heavy lower extremities, being connected by the top joint with the panel, comes up along with the latter into its angular position, its lower end dragging along in a race or guide upon the sill provided for it, and when the panel has been brought up a little beyond its proper berth the lower end of the spur-brace drops in behind a catch, which holds it there, and against which it abuts firmly as soon as the tail end of the panel is lowered and begins to receive the pressure of the water, the depth of which at this

NAVIGABLE CHANNEL OF THE UPPER BRIDGE.
PARTLY OPEN.
SHUT
FIG 1
SUMMER WATER LEVEL.
NAVIGABLE CHANNEL OF THE HARRIS & JOHNS.
FIG 2
LOWER REACH.
PHOTO-LITH. BY A. DICKES, 126 SOUTH 4TH ST. PHILA.

season is shallow. In Fig. 1 the water is shown at low summer level, but all this operation can be performed with the water level even above that of the top joints of the chevalet and spur brace.

The *chevalet* seen on the flat is an isosceles triangular frame of wrought iron, the lower joints or pivots being at the extremities of the base, at the level of the sill. The top joint is single, but wide in the jaw. Each panel, therefore, when in place is fixed at three points of base, besides its bearing against the sill rabbate at its lower edge. It thus is very stiff and secure.

All the catches by which the spur-braces are held in place are movable, and all connected by a sliding bar lying flat upon the sill, and moving within certain limits end on by the help of a rack at its extremity within the wing-wall or pier, and acted on by spur gear. When, therefore, the waters have risen to such a level that the pass can be opened for navigation these catches are simultaneously released, if desirable, and the entire line of *hausses* cant over at once into the horizontal position upon the top joints of the *chevalets*, and then at once *very quickly subside*, rather than drop down, in the water to their flat position at the bottom. The opening of a navigation pass of above 150 feet wide can thus be effected in *four minutes*. It takes about *an hour to close it again*."

Supplementing this with a portion of M. Cambuzat's description, cited in the report, we learn further, that,

"Each wicket is movable around an axis forming the cap of the horse, which itself turns around its sill, whose journals are held in two boxes fastened in the lower face of the sill of the pass. The wicket, when upright, is inclined at an angle of 15° from the vertical, and laps three inches against the upper face of the sill. The top is even with the surface of the pool. The axis of rotation of the wicket is so placed that the height of the breech above the sill is $5\frac{1}{12}$ of the total height, and consequently that of the chase is $\frac{7}{12}$. The cap of the horse passes through an eye in the head of a prop, whose foot is supported, when the wicket is up, against a cast iron heurter fastened in the sole of the pass. When the wicket is down the prop is retained in a slide, of which the heurter is the head. When it is desired to lower a wicket, the foot of the prop is tripped by a corresponding projection on the tripping rod, which is moved horizontally on the sole by means of a wheel and gearing placed in the pier or in a wall of the lock, for each pass is managed by two tripping-rods, each of which acts upon one-half of the wickets, beginning at the middle of the pass.

"On the other hand, the wickets, when down, are raised by a boat-hook worked from a boat furnished with a windlass and other appliances.

"It is quite evident that the trestles, the props, and the tripping-rods are of wrought iron; the slides and heurters of cast iron."

"This ingenious system," says M. Cambuzat, Chief Engineer *des Ponts et Chaussées*, "was striking in its simplicity, and was accepted at once after the isolated experiments made at a single dam."

The wickets used on the Yonne are from nine to ten feet in height. At certain stages of water they are partially automatic, but are in some cases worked from a boat fitted with machinery for the purpose,

and in others from a foot-bridge, ingeniously constructed so as to be removed when the wickets are down, and replaced when they are to be raised. The boat is shown in Fig. 1, the bridge arrangement, which seems to be preferred, and of which the following is a description, is shown in Fig. 2.

"Each bridge for maneuvering is composed of wrought iron trestles, like the trestles of Poirée dams, movable around a horizontal axis at right angles to the axis of the weir. Each trestle is opposite the middle of a wicket. These trestles are connected at their caps by two clamp-bars, which fix the width of the bridge. Between these bars is a wooden flooring, which is raised 20 inches above the level of the pool. The two clamp bars are the rails upon which rolls the truck that carries the hoisting windlass. Finally, to this windlass reach two chains, one attached to the head of the chase, and the other to the foot of the breech of each wicket. By the help of the windlass, solidly fastened to one or two trestles, and the two chains, every maneuver necessary to regulate the level of the pool—raising, lowering, or swinging the wickets—can be performed without fatigue and without danger. In times of flood the trestles of the foot-bridge fall into a recess nearly on a level with the crown of the weir. The planks, clamp-bars and windlass are put in store. The counter-weights have been removed from the weir-wickets as no longer required."

Our American engineers give full descriptions of the above and many other successful methods in use for closing the navigation passes, accompanied by drawings necessary for their comprehension, all of which will be found to be of great interest to the profession. The limits proper to this paper will only suffice for the one example, and to give the names of the principal methods they have examined. This last is done chiefly to show the great importance which attaches to the subject of river navigation abroad, and to interest others in devising a system more perfect and more suitable to the American rivers.

The following are the methods described in the report:

1. The "bear trap" gate.
2. The wicket used on the Rion.
3. Thenard shutters.
4. Thenard shutters as modified by Fouracres.
5. Poirée needle dam.
6. Combination of the Poirée needle dam and Thenard shutters.
7. Chanoine wickets.
8. Desfontaines wickets.
9. Modified Poirée needle dam.
10. Cuvinot drum-wickets.
11. Crants wicket with pontoon.
12. Carro gates.

13. Girard shutters.
14. S. Petidier's C. E. plan.
15. Capt. J. A. Wood's plan.
16. Col P. J. Schopp's C. E. plan.
17. Brunot's hydraulic gate.

The four last named and the first being American plans.

Objections.

The Board, after considering the merits and demerits of the plans, and instituting a comparison between the Seine and the Ohio rivers, greatly favorable to the latter as to its capacity for such works as are proposed, proceed to say :

"One objection to all the French systems, is that the mechanism consists of a great number of parts, all of which must be kept in perfect working order, a thing which is less difficult in France than in this country, because there is a long established and well organized and trained body of inspectors, engineers, and lock and dam-tenders, and assistants, whose lives are devoted to such work, and who are thoroughly capable of attending to it. The lack of such a body in the United States, makes it eminently desirable that all machinery should be of the simplest possible kind, and we believe the plan we recommend has at least this merit.

"Another and more serious objection to the French systems comes from the greater cold of our climate, and the greater danger of injury by ice. The account already given shows that the Seine dams were greatly endangered by an unusual cold of 21°. As this is a very common temperature with us, and as the thermometer is not unfrequently below zero, it is manifest that the danger mentioned would be both more frequently encountered in this country, and more dangerous when encountered, particularly in view of the higher and more sudden floods, and the greater masses of driftwood." And in another place, "The system now in use on the Yonne and Seine has the advantage of being the gradual growth of long years of study and experiment, and will undoubtedly, at least on the upper Ohio, radically improve the navigation. The question before us, therefore, is whether this system is the best that can be devised for such navigation as is used on the Ohio River, or whether we cannot obtain a method more suited to our wants."—(Report, page 80.)

American Methods Proposed.

The writer of this, in early life, assisted in the surveys for the

Monongahela navigation improvement, and has ever since been a persistent advocate of some radical improvement of the Ohio River.

The diversity of opinion among the engineers who had written upon the subject, as to feasible modes of improvement, and a knowledge of the requirements of the trade and the insuperable objection on the part of those engaged in it, to any plan which would obstruct the river in its navigable stages, led me to the conclusion that no system could be adopted which would not allow a free channel of two or three hundred feet wide in ordinary stages of water. To devise a method of shutting and opening such a sluice-way seemed to be the ultimate and only solution of the problem of an unobjectionable plan, provided it could be done on the principle then in my own mind and since laid down by Hagan, as cited in the report of Messrs. Weitzel & Merrill. About the same time, it became apparent that such a gate or movable dam was imperatively needed on the Monongahela slack water improvement, to permit coal fleets to pass the dams in high water without the delay incident to the ordinary lockage.

Believing that whatever ought to be done, in mechanical engineering, can be done, I set myself to the task of doing it in this case, and in the summer of 1867 devoted several months continuously to the subject. Among the plans devised during this time, several may be worthy of mention.

The first, promising satisfactory results, was a strong gate in a line with the axis of the dam, hinged along the up-stream side to the bottom of the sluice-way, and lying flat upon the bottom. From its down-stream lower edge, iron segments, with cogs on the inner side, projected downwards into wells, their length being something more than the height of the gate when raised. Under the lower edge of the gate, in the angle formed by it and the segments, was a recess containing a continuous shaft with a pinion at each segment working in its cogs. This shaft, driven by an engine from the shore, or a turbine wheel, would raise or lower the gate, or sustain it at any desired height. To the lower edge of the gate, I proposed to hang an apron of wood to protect the segments and shaft when the gate was raised.

This plan was unsatisfactory on account of the amount and character of the machinery, its liability to derangement from ice at certain stages of water, or other causes, and the liability of the wells to become obstructed by sediment, and was abandoned. I may say, however, that it still seems to me practicable and better than any of the French plans in use.

Another expedient, identical with the above, except that, instead

Fig 1.

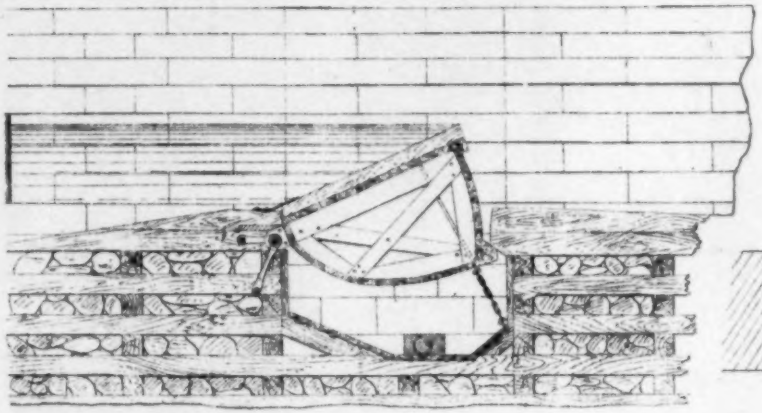
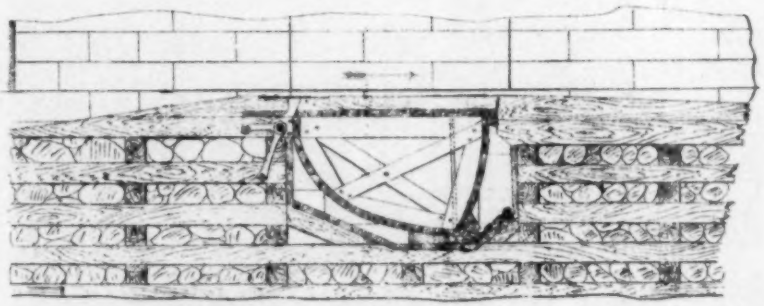
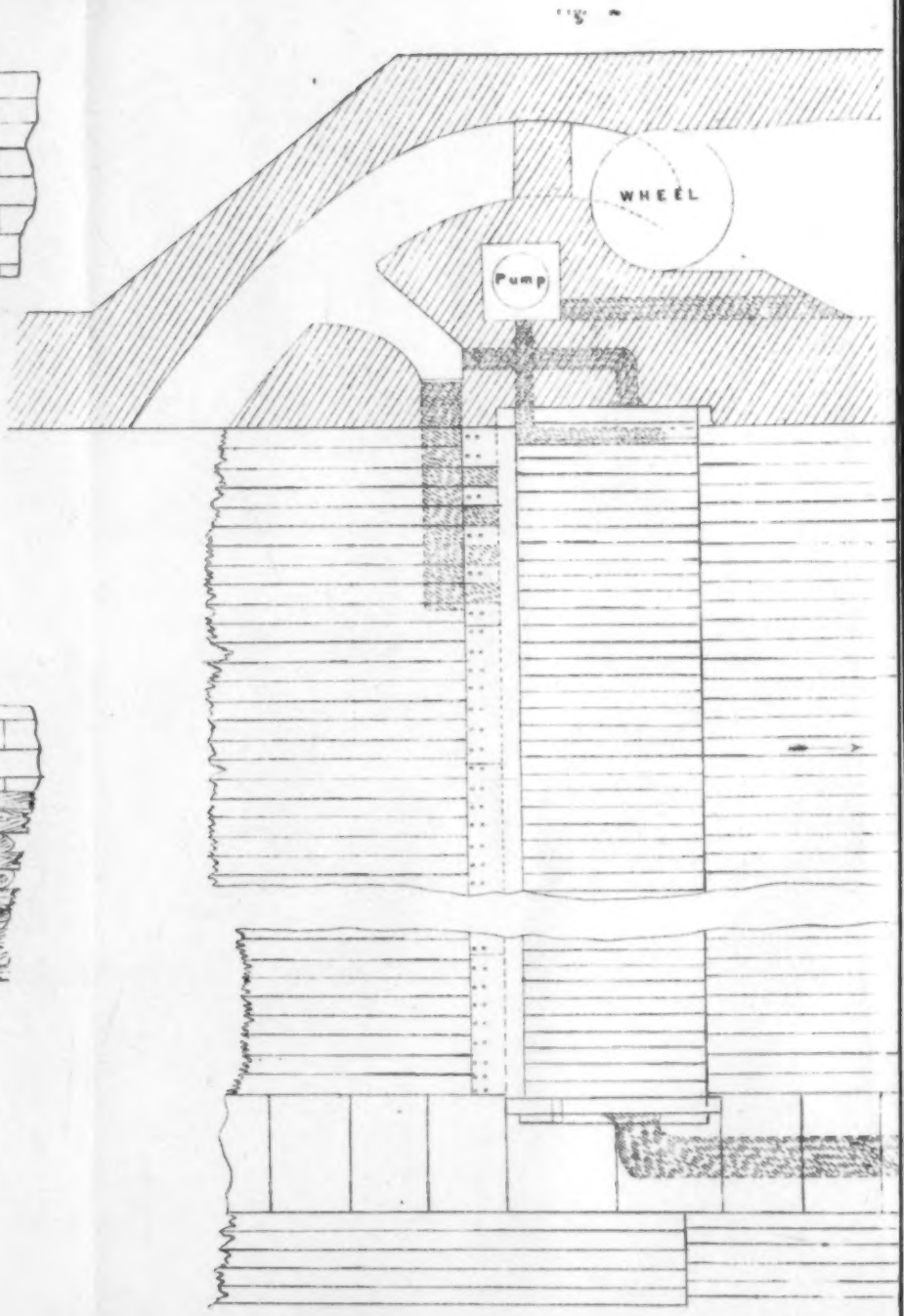
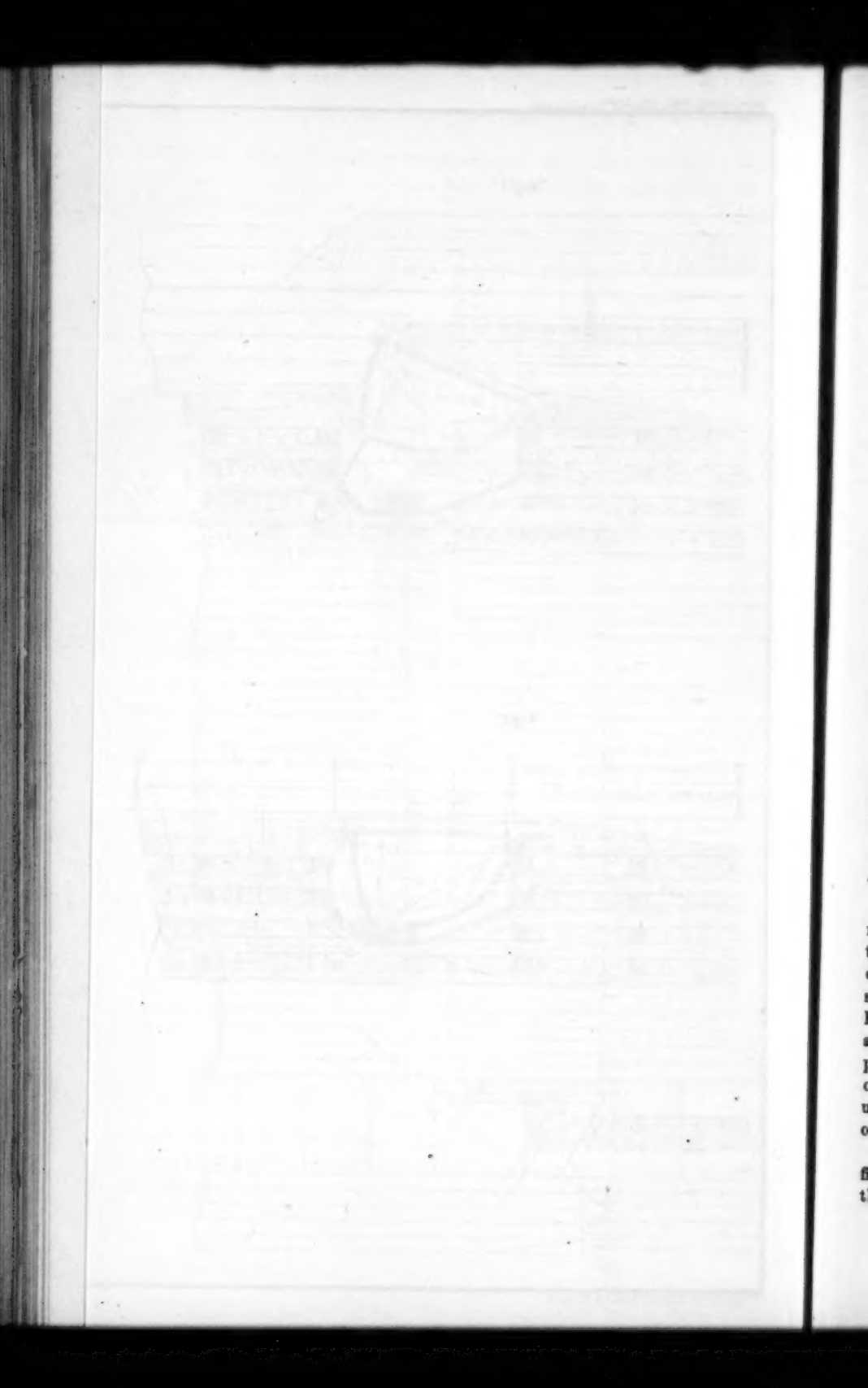


Fig 3.







of the segments and shaft, I proposed to place a series of hydraulic jacks in recesses under the lower edge of the gates, the water for raising their pistons to be forced through pipes by an engine upon the shore. This also seemed objectionable from liability to rust, damage, and breakage, and especially from freezing of the water in the pipes and jacks. I learn from the report of Messrs Weitzel & Merrill, that the same method was invented by M. Girard in 1870, for raising Thenard shutters on the Yonne.

Abandoning, then, the machinery idea, I fell upon the device of a strong pontoon, of proper size and depth, and of somewhat greater weight than the water its material would displace. This was to form the gate, working its ends perpendiculary in grooves in the face of the abutments, and relieved by friction rollers, its bottom resting in a recess of sufficient depth to receive the gate or pontoon when sunk. To raise the pontoon, I proposed to pump the water out of it, and to sink it by letting the water in. The plan seemed to have many objections, but was a step in the right direction—that of making the water and the air do the work—and which led to a result which seemed to fully meet the requirements of the case. After the construction of an operating model, the simplicity of the device, and its satisfactory operation, together with the manifest correctness of the principles involved, made it seem impossible that it had not already been somewhere adopted. On this point, an article in the *London Engineer*, of October 25th, 1857, describing the models of the plans for the improvement of river navigation, displayed at the Paris exhibition, was convincing as to its originality.

The following is the description of the plan as given in the report of the Ohio River Board, on page 78.

"The Hon. F. R. Brunot, of Pittsburgh, exhibited to the Board a small model of a floating hydraulic gate, which seems to meet the requirements of the case. Mr. Brunot only presented the model, leaving the completion of the details necessary to put it in practice to be elaborated by us. His system is shown, in section, on Plate 17, Figs. 90, 91, 92.* It consists substantially of a hollow caisson or pontoon, of the length of the desired opening, (see Fig. 92,) and of suitable width and depth. A chamber is excavated in the dam at the place chosen for the gate, and when the latter is in place and lowered, the top of the caisson is even with the floor of the pass, and the passage is free. The up-stream edge of the top of the gate is securely hinged to the up-stream edge of the gate-chamber.

Two methods of maneuvering the gate were proposed by the inventor. The first method was to make a connection between the chamber and pool above the dam, so that the hydrostatic pressure of the upper level might raise the

* Plate II, Figs. 1, 2 and 3.

gate. It could only rise in an inclined position, as the upper edge would be held down by the hinges. To lower the gate the connection with the upper pool would be closed and that with the lower one opened, and the gate would fall on the removal of the water pressure. The service of the gate would be simple and inexpensive, as one man only would be required, and his work would be limited to opening and closing valves. * *

The other method suggested by Mr. Brunot is to fill the gate with water when the chute is to be opened, and to pump the water out when it is to be closed. This will, undoubtedly, secure the desired result beyond any possibility of failure, no matter what may be the difference of level between the two pools, and this is the method which we recommend. The power necessary to do the pumping can always be had from the fall at the dam, and a turbine wheel in a well in the abutment would be the natural method of applying it."

The drawings given are somewhat different in details from the original plan. The terms movable dam, caisson, and gate, are used interchangeably both in the quotations and in the text of this article.

The report presents but two objections to the system, or its mode of operating, both of which refer only to the first named method of working the gates exclusively by means of the hydraulic pressure, and its own floating force, and neither to the mode of operating it by filling and emptying.

In regard to the first objection it remarks, further on:

"We found that by putting a shoulder on the lower edge of the Brunot gate, as shown in figures 90 and 91, we could retain sufficient play and make a tight fit against the chamber wall."

Certainly this obviates the objection if the wall of the chamber is curved to correspond with the lower face of the gate. If the chamber is of masonry, as it ought to be, this may be deemed the better form. In the original model I assumed that the gate would be made of iron, as the best material, and the chamber of wood, for cheapness, and would be rectangular in shape. To obviate the difficulty in question, a lip, intended to be adjustable, is provided at the top of the chamber, and projecting to the face of the gate so as to touch, or nearly touch, it at all points as it moves up or down. There is also a projecting lip on the lower edge of the gate, and one on the upper edge. Thus, when the gate is up, the surfaces make a tight joint, and, when down, the lip at the top serves the same purpose, and when moving, that on the top of the chamber answers the same purpose.

In regard to the other objection, the mode of sinking the gate when the water in the lower level is even with the top of the chamber,

is to let the water into it by opening the valve, when it will immediately sink.

If the gate is made of wood, it should, of course, be permanently ballasted, so as to be somewhat heavier than the specific gravity of its material. The chute being open in the above-named condition of the water no contingency can occur which would require it to be closed until the water, has fallen below the level of the top of the chamber, and as soon as this occurs, the pressure of the higher level of water above the dam becomes available to raise the gate and close the chute in the usual way, the water it contains escaping from its open valve as it rises. This explanation, it will be seen, entirely removes the objection in any case where the top of the chamber, and of the gate when occupying it, makes at a moderate or low stage of water a difference in level between the upper and lower pool, as must necessarily be the case in the proposed chute in Dam No. 1 on the Monongahela River, and in such cases obviates the need of pumping apparatus.

To construct the dams and chutes upon the Ohio River on the same plan of creating so considerable a difference between the level in the upper and lower pools, would leave a free downward navigation as long as the water is deep enough in the chute to permit, but probably would compel the up-stream craft to pass through the locks, even at ordinary stages of water. This does not accord with my idea of the best improvement, which is to leave the river as available as now, for both upward and downward navigation, as long as there is sufficient water in the chutes for the draft of steamers. When too scant for this the movable dam would be raised and the pools filled, thus creating a lock and dam navigation for the upward trade, and continuing the downward navigation as before by dropping the gates for the passage of boats or fleets, and immediately raising them after each passage.

On this plan the bottom of the chutes must more nearly approximate to the bottom of the river, and the dam would require to be raised in slack water, or, at best, in only a rapid current, which would afford no power adequate to the purpose. This led me to adopt the method of filling the movable dam to sink it, and pumping out to raise it.

I fully agree with the Board that this method is unobjectionable in its operation and effectiveness, and cannot fail of success. I consider their mode of applying the pump admirable, although hardly so good as my own. I proposed to fix at the end of the axis of the gate a pipe corresponding therewith and extending by an elbow to the

bottom of the gate. This pipe, which moves with the axis of the gate, extends into the abutment, and connects with the suction pipe by the ordinary plan of hose coupling. The same pipe to be used for filling the gate by admitting the water through a perpendicular to the suction pipe near the coupling, and closed by a valve. The following is the method of application proposed by the Board:

"There are two methods of filling the gate—by opening the valves in the top of the gate itself, or by opening a pipe which communicates with the interior of the gate. As the gate rises and falls around a horizontal axis, there is some difficulty in devising an apparatus to move these valves at all times which shall itself be sheltered from floating bodies. Moreover, valves in the top of the gate are liable to injury, and they weaken the gate where it ought to be strongest. For these reasons we propose to permit water to enter by a pipe under the platform of the chute, which shall connect with the interior of the gate by several branches of flexible pipe entering just below the hinges. The main pipe will be controlled by a valve worked from the abutment, as shown in Fig 92. It is calculated that a two-foot pipe will fill the experimental gate, 100 feet in length, in 2 minutes, which is, probably, quick enough. To empty the gate a centrifugal pump is used, whose suction pipe has a flexible length to connect it with a pipe extending to the bottom of the gate. This pump will be set in motion by a turbine wheel. The necessary power to drive this pump was calculated by assuming five minutes as the time for the work and taking the capacity of the experimental gate as 5,000 cubic feet and the lift as six feet. We, therefore, have a quantity of work of 375,000 foot-pounds per minute, or 11·4 horse-power. The effective work of pumps is given by Bourne as ranging from 30 to 65 per cent. of the power applied to them, and, therefore, with an assumed efficiency of 38 per cent. we find that we require 30 horse-power to work this pump.

To get the size of turbine necessary to develop this effective power we use Francis's formula.

$$D = 4{\cdot}85 \sqrt{\frac{P}{h \sqrt{h}}}$$

in which P = 30, the effective horse-power, and

h = 6, the assumed head of water. We, therefore, find—

$$D = 6{\cdot}93 \text{ feet.}$$

The amount of water necessary to supply this wheel is found by the formula also given by Mr. Francis:

$$Q = 0{\cdot}5\ D^2 \sqrt{h}$$

Whence we find—

$$Q = 58{\cdot}8 \text{ feet per second.}$$

To supply this amount of water without great velocity, and, therefore, without sensible loss of head, the water in the channel leading to the turbine should have a velocity of not more than 3 feet per second; and, therefore, the cross-section of the channel should be about 20 square feet. We have, therefore, taken

a width of four feet and a depth of five. The positions of the pump and turbine are shown in Fig. 92.

It is important to have some arrangement for the automatic filling of the gate, should a sudden flood come in the night, or when the gate-tender was absent or negligent. This is provided for by a stationary pipe at the far end of the gate, which is sheltered from floating bodies by the recess at that end of the chamber. The height of this pipe is such that when there is a greater depth in the chute than seven feet, the water overflows into the gate. This pipe also answers as an air-pipe during the maneuvering of the gate.

The most important navigation on the upper part of the Ohio River is the transport of coal, and as this transport is always down stream, and as the ponderous coal-fleets are not easily checked or stopped, it is very desirable that the process of lowering the gate and opening the pass should be very expeditious, while there need be no great hurry in raising the gate. The system proposed answers these ends perfectly. One man can maneuver the gate, and it can be filled with any desired rapidity, If the two-foot pipe should not do the work fast enough, there is no difficulty whatever in using one of greater diameter. After the fleet has passed, the attendant has only to open the gate of the turbine, and in a few minutes the pass is closed. It seems hardly possible to devise a system that could promise better results.

In order to scour out any sediment that may accumulate in the chamber, a culvert is made at the far end, and inlet pipes at the abutment. As this operation would seldom be necessary, (possibly once a year,) it is believed that the management of the valve at the far end would offer no practical difficulty. Excepting this one valve, all the mechanism is on the abutment, and is, therefore, always accessible."

Although the mode of operating it by filling and pumping out the gate is unobjectionable in its working, there is a third plan, which, if a pump is used, may be found to be preferable, viz., *to pump in air* through the hollow axis, which will by its pressure displace the water, a valve in the end at the lowest point being opened for its escape.

Nevertheless, a pump of any sort, with its propelling power, is additional machinery and more liable to breakage or disorder than a simple valve or wicket, and for this reason I devised a plan to work the gate effectively without that aid.

It is proper in this connection to say that having had but a short interview with the Board at the time my model was examined, nearly a year ago, and not being aware of their continued and laborious experimental investigation of the subject until after the publication of the present report, neither this plan or that above-mentioned has been submitted to the Board.

It is evident that the gate will not be wanted, nor can any necessity occur for raising it until the water in the natural channel and in the sluice, falls to a depth of say five or eight feet, or whatever may

be assumed as the minimum for navigation. When this point is reached and the gate is *once* raised, the dam it forms will create a head which will give the power to raise it again as often as it may be dropped for the passage of craft. In the process of rising, it would itself create the power to continue, and accelerate the upward movement.

I propose to place a tank or reservoir either in the abutment or on shore, which will fill in the flow of high or ordinary stages of water, and by closing an automatic valve retain the water until needed to raise the gate. This would be done simply by opening the valve of a duct connecting the reservoir with the chamber, and opening the valve in the end of the gate to permit the escape of its contents.

This device, it seems to me, fully overcomes the objection suggested, and renders the pumping arrangement unnecessary.

But even this addition is not necessary to properly work the proposed movable dam or gate on the Monongahela; nor will it be necessary upon the Ohio River, if the level of the bottom of the chutes shall be placed at any similar height above the bottom of the stream. In any event, the movable dams suitable for the Ohio need only differ from that required at Dam No. 1, on the Monongahela River, in dimensions, and that can be increased to scale in all the parts, as far as may be desired. I therefore proceed to describe the

Proposed Plan for a Chute and Movable Dam on the Monongahela River.

It consists of the following parts: The chamber of masonry A, Pl. III, 104 feet long, 12′ 3″ wide, 4′ 6″ deep, the top being 4′ below the comb of the permanent dam; 4 feet of the length of the chamber being in a recess in the abutment C, Fig. 4, is 1′ 6″ deeper than the other part, to permit the working of the down stream wickets. Forming so much of the top of each wall is a timber D and D^1; that on the upper wall to be formed on its corner into a hollow quoin for the heel of the movable dam or gate, and that on the lower wall shaped to form a stop and rest, and a tight joint when the gate is either up or down, and a joint with the curved face of the gate when moving. The timbers to be firmly anchored beneath the masonry by bolts.

The movable dam or gate, B, made of iron, 100 feet long, 4′ 3″ deep outside, 12′ 6″ wide on top, including the heel or hinge, which is 6″ in diameter. The heel is held or hinged with strong iron straps, 20 feet apart, and securely fastened. The down stream face is, in its

Fig 1

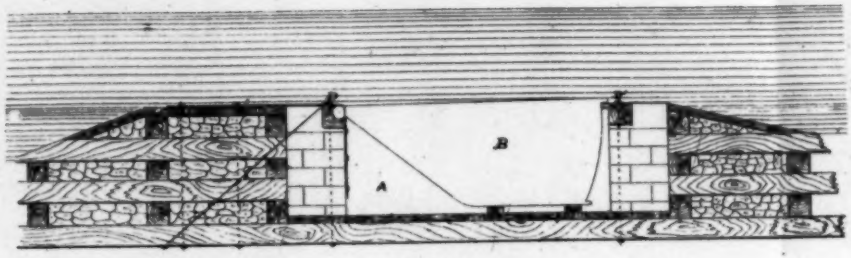


Fig 2

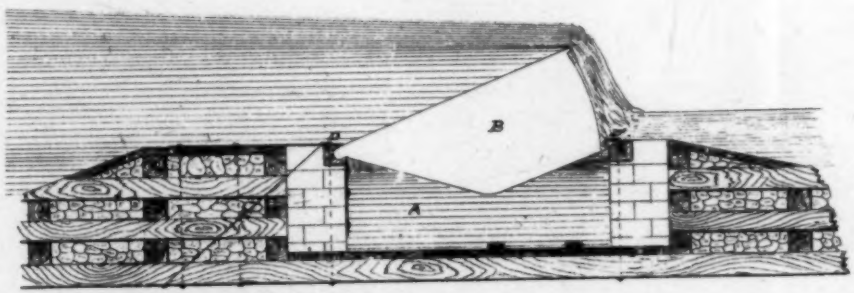


Fig 3

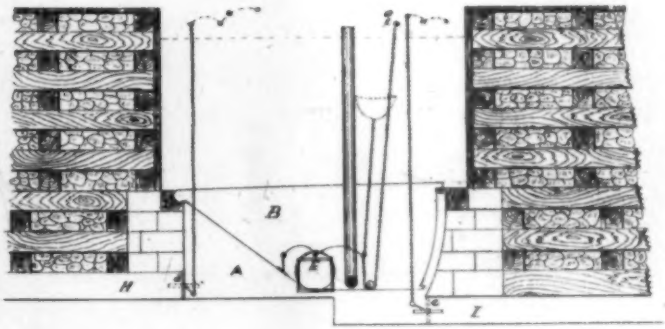
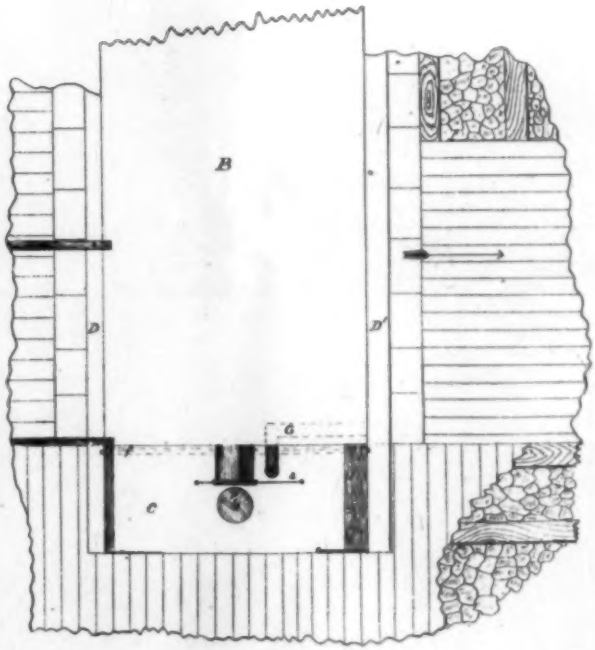


Fig 4



DET. AND PHOTO-LITH. BY A. SINGLER, 720 SOUTH 4TH ST. PHILA.

perpendicular direction, a segment drawn from the axis as its centre. The bottom, and back, or up stream side, is extended beyond the end of the gate into the recess of the abutment, 4 feet, to the wall. The top and front sides terminate with the end, at the face of the abutment. This projection forms a floor, which divides the recess from the part of the chamber beneath it. In this floor is a man-hole, E, for access to the chamber.

In the end of the gate, projecting into the recess, and at the point which will be lowest when the gate is up, is a pipe, F, closed at its outer end by a slide valve, and large enough to serve also as a man-hole.

Attached to the top of the valve is a lever, *a*, at the end of which is a chain holding a float, which will draw upon the chain and partly open the valve, whenever the water in the river rises to a height of three feet above the comb of the dam. At the same time, a similar float attached to its lever will open the lower wicket, and permit the water to escape from the chamber.

This arrangement is for the purpose of sinking the gate automatically, in case of sudden floods at night, or in the absence of an attendant.

As it is desirable to admit no more water than is necessary to sink the gate, another chain, *o*, attached to the end of the lever *a*, passes down through a pulley fixed on the projecting floor, and thence to the top of the abutment, where it is fastened. This chain is slack—the slack being equal to the difference between the sweep of the lever and the perpendicular fall of the gate at the point of attachment. When the gate sinks it draws down the lever and closes the valve.

The purpose of the above devices, viz., the admission of water and stopping it when enough has entered, may be also effected by a stand pipe, rising from the top of the man-hole pipe to the proper height, and with a valve on the top, the normal condition of which would be open. A chain attached to the valve passes down through the pipe, around a pulley at its angle, and, entering the gate, is there fast to a float, which, when the desired quantity of water has been admitted, draws upon the chain and closes the valve at the top of the pipe.

There is a stand-pipe, G, for admission and egress of air, which enters the end of the gate by the side of the water pipe, and by an elbow and arm reaches to near the top of the gate inside. Its outside arm rises to the top of the abutment.

There are ducts, H and I, leading from the end of the chamber be-

neath the gate to the upper and lower pools, respectively, closed by wickets, *d* and *e*.

At the further end of the chamber there is a communication with the lower pool, closed by wickets.

The recess in the abutment is separated from the chute by a partition, *f*, which extends two inches below the top of the gate when it is down. The down stream end of the recess is curved from the bottom to the top of the chamber, so that the projecting bottom of the gate will nearly touch at all points, as it rises or falls.

The wickets, gate valve, stand-pipe, levers, floats and chains are all within the recess, and worked from the top of the abutment. They are protected from the drift of submerging floods by an iron trap door, which is closed by hand, or automatically by the sinking of the gate.

The Principles and Mode of Operating.

The forces brought into requisition are—

The floating power of the hollow water-tight caisson or gate.

The hydrostatic pressure due to the difference in level between the upper and lower pools.

The support given to the gate at every point by the inelastic body of water confined in the chamber beneath it, and which is approximately equal to a solid foundation.

The gravity of water introduced to sink the gate in certain contingencies.

The mode of operating is—

1. The gate being down, and the pass or chute open, it is raised, and the pass closed, by shutting the down-stream wicket, and opening that which connects with the upper pool.

2. The gate being up, it is dropped by shutting the up-stream wicket and opening that which connects with the lower pool.

3. If the back water is above the top of the chamber, the valve in the gate is opened, and the down-stream wicket at the same time, and the gate will sink.

This contingency can only occur in extreme high water, and when it occurs the gate will not be needed until the water falls again below the chamber. The gate will then rise by the adjustment of the wickets, and opening the valve for the escape of its contents.

When sediment accumulates in the bottom of the chamber, the wicket communicating with the upper pool, and the wicket at the further end of the chamber, connecting with the lower pool, are both

opened, and the strong current through the length of the chamber will wash it out.

Other Considerations.

The slope of the upper side of Dam No. 1, on the Monongahela River, is 3 to 1. I have, therefore, made the slope of the movable dam to correspond, and this fixes its width.

The shape of the bottom may be varied. I have chosen that shown in the drawing as being simple and of easy construction, and as dividing the upward pressure of the gate when raised nearly equally between the heel and toe of the gate. The amount of displacement and best form of the bottom is a matter of easy calculation, depending in part upon the specific gravity of the material used. It should be such that if the gate were lying unhinged in open water, the heel and toe would rest a little above the surface. It is manifest that with several feet of water above the top of the gate its tendency to rise will be vastly increased both by the enlarged displacement and the added pressure beneath. Hence the necessity of strong fastenings for both the quoin and toe timbers and the hinge straps. The resistance to be provided against by these, at whatever stage of water, is a matter of calculation.

The rectangular form for the chamber is preferred because it is easy of construction, and gives ample room beneath the gate for examination or repairs of the bottom. This can be done in low water by placing temporary props under the lip to hold it in its raised position, and letting out the water from beneath it.

In regard, further, to the application of this plan to the Ohio River, should it prove successful upon the Monongahela, it will require very little modification. Although the Board of Engineers assume 200 feet as the width of chute they propose, there is nothing in the plan of the gate which will necessarily limit it to that length. Its ample interior gives room for any degree of strength needed, and its principles of support and operation will apply to any length.

A caisson or craft of similar dimensions, resting in open water, could hardly be prevented from hogging. In this case the gate when up is sustained in its whole length by its quoin resting on the wall, and by the *equal* upward pressure at all points of the confined body of water upon which it rests. *No amount of load can force it down unless the water can escape from the chamber.* When it is down, it rests on the quoin, the toe projection, and the sills under the bottom.

The time required for the raising and dropping the gate is controlled by the size of the wickets and ducts; and by placing these, as they should be placed in a long gate, at several points, *it may be easily made to drop or rise in one minute.* The wickets would be the common lock-valve wickets, working on perpendicular centres, located at intervals along the face in both sides of the chamber, those on each side connected by short levers to a horizontal rod extending along the inside of the chamber to the recess in the abutment, and there worked by a common upright straight lever, which would open or shut them all by one motion of the hand.

Conclusion.

Whilst the Board of United States Engineers in their report have expressed, almost as strongly as the inventor, their confidence in the success of the plan they recommend, and pointed out very clearly its superiority to any of the foreign systems in use, they nevertheless very judiciously and properly confine themselves to a recommendation that it should be tested. They remark:

"Should the system which we recommend for trial be adopted, we will find ourselves provided with a navigation that differs in many particulars from that used in France. In the latter country, as soon as the natural depth in the river is less than 5 feet, the passes are closed, and all navigation in either direction is carried on through the locks. On our system, if we can get a gate, as we think we can, that can be opened in two minutes, and closed in five, it will be quite practicable to keep up an intermittent down-stream navigation through the pass throughout almost the whole year, as the opening of the gate for not to exceed ten minutes at a time, which, allowing for diminished discharge while being opened and shut, will make the total expenditure of water about equal to a full opening of the chute for five minutes, will probably not injuriously lower the level of the upper pool. We would thus have a natural down-stream navigation throughout almost the entire year, which would be an immense advantage, since our heavy products, such as coal and manufactured iron, all go down the river. To counterbalance this advantage, we would have the disadvantage of forcing all up-stream navigation, except in very high water, to pass through the locks. The latter would have to be higher than the French locks, and our expenditures for masonry and timber for the dam, and inclined plane, would much exceed theirs. To counterbalance this, we have simpler constructions, less complicated mechanism (which is both very costly, and must be carefully watched and kept in order), and probably less expense for attendance. It is, therefore, mainly on account of the special character of our climate, and of our navigation, that we recommend that a system differing from those used in France be first tested, in preference to copying what are successful in their native country, but which might not work so well here. We wish it to be specially understood that, while we have attempted to collect all available information on this subject, we do not presume to decide the question now, but limit our-

selves to recommending a preliminary experiment. * * * * * * * * * * * * * If it is a success, there need no longer be any difference of opinion about the radical improvement of that river. As such vast interests depend upon this trial, they would most urgently press its importance upon Congress."

The report concludes with the statement that the Monongahela Navigation Company, being desirous to have a navigation-pass constructed in Dam No. 1, through Hon. J. K. Moorhead, President of the Company, has offered that work for the experiment, agreeing to pay one-half the cost, "we would, therefore," they say, "urgently recommend the appropriation by Congress of $40,000 for the purpose of experimenting with a navigable chute, to be opened and closed by a hydraulic gate, in one of the dams of the Monongahela Navigation Company," &c.

Undoubtedly an actual test, upon an adequate scale, is the only possible mode of reaching a safe conclusion, and the test must inevitably be made, sooner or later, by the General Government. Why not make it now?

It can be shown that, aside from the great questions of cheapness of transportation, the increased cost of fuel to the West and South owing to the fitful and precarious character of the present navigation, and other considerations, making up an aggregate of transcendent importance, the loss of interest on capital invested in craft and their burdens, whilst idly waiting for a movement of the waters, is annually greater than the appropriation the Ohio River engineers ask for their experiment. A noble river, which reaches by steam navigation the States of New York, Pennsylvania, Ohio, Virginia, Kentucky, Tennessee, Indiana, Illinois and Missouri, and at its mouth connects with the Mississippi and its tributaries, reaching by a similar navigation the States of Mississippi, Louisiana, Arkansas, Iowa, Wisconsin, Kansas, Nebraska, and the Territories of Dakota and Montana, inhabited in all by more than twenty-five millions of the people; a navigation which washes a shore line greater in length than the Atlantic, Pacific and Gulf coasts combined, and with a greater number of harbors, is certainly of national importance; and Congress cannot much longer delay to take the necessary steps towards such a radical improvement as will render its navigation perennial.

Pittsburgh, April 4th, 1874.

Chemistry, Physics, Technology, etc.

SECOND CHEMICAL AND SANITARY REPORT UPON THE WATER SUPPLY OF THE CITIES OF NEWARK AND JERSEY CITY.

By Professor Henry Wurtz.

(Corrected and prepared for this Journal by the Author.)

Hoboken, October 1st, 1873.

To the Joint Commission of the Jersey City Board of Public Works, and the Newark Aqueduct Board:

Gentlemen:—On the first day of July last, I first received from your Honorable Commission, by the hands of His Honor, Mayor Ricord, of Newark, definite written instructions, to renew and continue the investigations begun by me in October, 1872, by order of the Board of Public Works of Jersey City (of which a report was rendered by me under date of March 1, 1873, to that Board), upon the pollution of the Passaic River by sewage.

I was instructed to make chemical examination, also, of the water conveyed by the Morris Canal, regarding its availability as a source of pure water supply to your two cities.

Much traveling had to be done by me in collecting samples, and in examining at different times the condition of the water in the river and the canal. By dint of unremitting confinement to my laboratory in the intervals, however, a great number of analytical determinations have been accomplished, leading to results of the highest interest, which include, I believe, full chemical data for the settlement of the important questions pending—questions which intimately involve the future welfare of your cities for all time.

Field-Work and Collection of Samples.—On July 8th and 9th an examination was made of the upper Rockaway, and of the Canal from Denville through Rockaway and Dover, and up to the Hopatcong feeder. July 23d the lower Passaic was carefully reconnoitered from Newark up to Passaic, and four samples taken, at both extreme high and extreme low tide, at the Newark and Jersey City pumping-stations in Belleville. July 24th I drove up along the river and canal very nearly to Beavertown, and back again, the waters being carefully inspected and examined at various points, including the canal feeder across Pompton Plains, which was followed on foot for a con-

siderable distance. Samples were secured of the Passaic above the falls, of the Pompton feeder, and of the canal near Beavertown. The samples taken July 23d and 24th are of especial value and importance, as the river was then at about an *average* height, and not in the low state it usually assumes during that month. It will be recollected that the month of June of this year was exceptional, being the *very dryest*, and one of the hottest Junes on record, and that this drought continued till somewhere about the middle of July, but that during the latter half of July considerable rain fell.

July 28th an expedition was made up along the Rockaway River and Canal, from Rockaway to the foot of Lake Hopatcong, examining particularly the summit level, the Hopatcong feeder, and the lake itself, the shores of which were followed round on foot for a considerable distance. Samples were taken from the margin of the lake itself, that is, from the surface (there had been a very heavy rain during the previous night which had raised the level of the lake two inches), and from the outlet; the latter representing water emitted through a gate some ten feet below the surface of the lake. It was thought undesirable to take a sample from the feeder itself, as this *might* have shown fecal and urinary contaminations from the horses and boats occasionally traversing it at present. Should the feeder be closed to navigation, it will, of course, convey the water of the lake without such contamination, or just as the analysis represents it.

On the 13th of August, Messrs. Bailey and Hartman* kindly collected for me a sample of the water from the channel of the river, in Newark, at extreme high tide, off the Bridge street bridge. On the same day these gentlemen procured for me samples of the water from three of the public street *pumps* in Newark, which I have since examined, as set forth below.

During the month of August several successive appointments were made to make another expedition to examine the lower Passaic together, minutely, from Newark up to and through Paterson, as well as to collect samples of the August waters for analysis. These were all baffled, however, by the continuous rains, which kept the river somewhat flooded, even during that month, besides rendering exploring impracticable.

August 20th, another expedition was made to procure samples of the water in the city of Newark. Samples were taken—one from the

* Mr. Bailey is the Chief Engineer of the Newark Aqueduct Board; Mr. Hartman being an assistant of my own.—H. W.

TABLE I.

Analytical Results upon Clear Settled Waters—Reduced to the U. S. gallon of 58,327·5 grains of distilled water.

Number.	(1) SAMPLES.	(2) Total Solid Constituents.	(3) Loss on Incineration in Porcelain.	(4) Ash.	(5) Nitric Acid.	(6) Saltpetre, equivalent to the Nitric Acid.	(7) Combined Ammonia.	(8) Urea, equivalent to the Combined Ammonia.	(9) Ammonia, derived from matters of Animal origin.	(10) "Albumenoids" (by Wanklyn & Chapman's hypothesis)	(11) Chlorine.	(12) Common Salt, equivalent to the Chlorine.
1	Newark Water Works—High tide—July 23	5·995	0·647	5·348	0·278	0·520	0·012	0·021	0	0	0·433	0·713
2	" " " Low " " 23	5·455	1·105	4 350	0·233	0·433	0·023	0·041	0·087	0·875	0 332	0·547
3	Jersey City " High " " 23	6·178	0·722	5·456	0·374	0·700	0	0	0·029	0·292	0·288	0 476
4	" " " Low " " 23	5·407	1·175	4·232	0·374	0·700	0	0	0·012	0·117	0·216	0·356
5	Hopatcong—July 28. Depth of Lake	1·702	0·455	1·337	0·300	0·561	0·006	0 010	0·012	0·117	0·101	0·166
6	" " 28. Margin of Lake after heavy rain	1·905	0·941	0·964								
7	Morris Canal, near Beavertown	4·231	0·881	3 350	0·186	0·347	0	0	0	0	0·144	0·238
8	Canal Feeder on Pompton Plains	3·332	0·764	2·568	0·139	0·260	0·003	0·005	0·029	0·292	0·115	0·190
9	Passaic River—head of Falls—July 24	4·584	1·501	3·083	0·334	0·624			0·023	0·234	0·252	0·416
10	Bergen Distributing Reservoir—June 23	4·203	1·117	3·086	0 280	0·520	0·023	0·041	0·044	0 437	0·288	0·476
11	" " " August 9	6·066	1·866	4·200	0·186	0·347	0·017	0 031	0·073	0·729	0·389	0·642
12	River in Newark—Flood Tide—August 13				0·094	0·175	0·017	0·031	0·058	0·583	632·77	1042·733
13	Ocean Water—Coney Island Beach—August 12				0·094	0·175						
14	Croton Hydrant—August 8	4·887	1·849	3·038	0·278	0·520					0·360	0·595
15	" " August 22—after heavy floods				0·185	0·347						
16	River in Newark—just before ebb—August 20—1 P. M	5·249	1 575	3·674	0·187	0·350	0.058	0 103	0·117	1·167		
17	" " just after flow began—August 20—3 P. M	5·833	1·458	4·375	0·037	0·070	0·029	0·052	0·292	2·916		
18	Public Pump—Newark, Market Street—"Register" office	21·380	1·449	19·931	1·669	3·121			0·155	1·552	2 790	4·710
19	" " " Corner Orange and Broad streets	21·290	8·750	12·540	1·853	3.465	0·017	0·031	0·070	0·700	3·100	5·233
20	" " " Corner Belleville street and 7th ave	15·400	7·410	7·990	0·555	1·038	0·026	0·010	0 078	0·776	0·930	1·570

The incineration was in every case conducted at the lowest possible temperature, in porcelain capsules, over Bunsen burners. The ash was in every case white, or nearly so, and is reserved for further examination.

channel off Madison street (below the discharge of the sewers), just before the time of ebb; a second from just above the opening of the Branch-brook sewer (the most northerly sewer), just after the beginning of rise of tide.

August 22d a sample was procured of the water of the Atlantic ocean, in which I desired to make a determination of nitric acid, for comparison.

Finally, another opportunity was had by me to inspect the condition of the river and canal at some points, during a journey along their line on September 22d.

Samples of Croton water were also obtained for comparative examination as regards chlorine and nitric acid.

The *preservation* of these samples of water during the summer heat in an unaltered condition being a problematical matter, the device was resorted to of keeping them in an ice-box provided specially for the purpose.

All the results presented in this report were, as is habitual with me, obtained with my own hands, and by my own labor exclusively. The analysis were confined to the determination of the following—being those ingredients which bear, or are believed bear, witness regarding sewage pollution :—

The total solid constituents.

The loss on incineration, and the ash.

The nitric acid and nitrates.

The combined ammonia (including that of urea).

The ammonia derived from proteine bodies.

The chlorine and common salt.

In order to secure uniformity for chemical comparison, it was obviously necessary to make all these determinations upon the waters after settling perfectly clear, that is, to confine myself to the ingredients in actual solution.

For comparison, I add here another table, in which the results reported last March, upon the waters of October and December of last year, are arranged in a similar way.*

* Last year means 1872. See *Journal of the Franklin Institute* for July, 1873. —Ed. Jour. Franklin Inst.

TABLE II.

Number.	[1] SAMPLES.	[2] Total Solids.	[3] Loss on Incineration.	[4] Ash.	[5] Nitric Acid.	[6] Saltpetre, equivalent to the Nitric Acid.	[7] Combined Ammonia.	[8] Urea, equivalent to the Combined Ammonia.	[9] Ammonia, derived from matters of Animal origin.	[10] "Albumenoids" (by Wanklyn & Chapman's hypothesis)	[11] Chlorine.	[12] Common Salt, equivalent to the Chlorine.
	JERSEY CITY WATER WORKS.											
21	Low tide—Oct. 10, 1872..	5·190	1·836	3·354	0·193	0·361	0·010	0·018	0·004	0·044	0·151	0·248
22	High tide—Oct. 10, 1872.....	4·783	1·896	2·887	0·338	0·632	0·004	0·007	0·011	0·107	0·292	0·482
23	Rec'g reservoir, Oct. 10, 1872	4·767	1·442	3·325	0·241	0·451	0·009	0·016	0·008	0·031	0·216	0·356
	HOBOKEN HYDRANT.											
24	Mean of Dec. '72 and Jan. '73..	4·107	1·198	2·909	0·280	0·524	0·005	0·009	0·005	0·047	0·152	0·251

DISCUSSION OF THE ANALYSES.

1. *The Lower Passaic (below the Falls).*—The analyses to be immediately considered under this head are numbered 1, 2, 3, 4, 10, 11, 12, 16, 17, 21, 22, 23 and 24.

The Solid Constituents.—A number of curious facts are developed by an attentive study of the figures in columns 2, 3 and 4. But few can occupy space. In the first place, considering the ash, or fixed mineral matters—(column 4), it will be seen that there was more in solution during the rainy period—(Nos. 1, 2, 3, 4, 11), than during the drought—(No 10). The mean of 1, 2, 3, 4 and 11 is 4·717; No. 10 being but 3·086. Next, the high tide waters contain more mineral matter than the low tide; the mean of two results, closely concurrent in each case, being in the high tide—Nos. 1 and 3, 5·402, and in the low tide—(Nos. 2 and 4), 4·291. This difference cannot be due to mixture of the upward tide with brackish water, for the chlorine—(column 11), would then show it, but would seem clearly due to the mineral matters imparted in solution by the Newark sewage. Complete analyses only could show, fully, the nature of these changes.

The low tide waters contain much more volatile and combustible matter than the high tide, and, during the flooded month—August (see No. 11), this underwent a further large increase. The substance brought in by the floods is, doubtless, chiefly vegetable or peaty matter. It will be observed that August 9th the ash was rather less than in July, though more than during the drought in June.

Nitric Acid and Nitrates.—Here the writer's results, *at first*, somewhat puzzled him. He had adopted, in the former report, the views

of that school of chemists which deems the presence of *nitrates* to be the most valuable index to sewage contamination; certainly, in cases such as this, where no geological formation, liable to contain nitrates, is concerned. As an example of the views of this school, Dr. Frankland said some four years since that, after the most diligent search, he had "failed to discover the slightest evidence of the formation of nitrates from vegetable matters. Whenever nitrates are found in England or abroad, they can be traced generally, with the utmost ease, to animal sources, and whenever such sources are absent, nitrates are absent, too, although considerable quantities of combined nitrogen may be present. It would be a wonderful thing if the water of the chalk wells did not frequently contain nitrates, considering that it is derived by percolation from the sewage and manure-stained soil above."

A little consideration, however, and especially a little exploration along the banks of the lower Passaic, during the heats of summer, suggests most conclusively that there are, with us, very potent disturbing influences, which, *in the summer season*, practically interfere with the chemical investigation of the nitrate question. Between Newark and Belleville the river, for long distances, was almost a continuous thicket or plantation of vigorous water-weeds, and the tide, while rising, was sifted or filtered through this immense mass of growing vegetable matter. It is no wonder, then, considering the well-known power of vegetation to absorb and assimilate nitrates and ammoniacal compounds, that, in summer at least, the proportion of these that would be expected to result from the drainage of Newark, should be disturbed. Hence it happened that the proportion of nitrates found in the upward and downward flows of July 23d, at the Jersey City Water Works at Belleville, was found the same. This growth of weeds extended all along the channel, even above the Newark Water Works. Hence the further loss of one-tenth of a grain per gallon of nitric acid during the flow of but one mile from the Jersey City up to the Newark Works.

In the fall or winter, however, after this vegetative process has ceased, the nitrate test for previous sewage contamination may doubtless be made use of—at least as a comparative test—though some further and still more remarkable facts yet remain to be set forth on this subject.

Combined Ammonia (*including Urea*).—The proportion of this found in these Passaic waters, above Newark, is mostly so trifling

that little can be deduced from it with certainty. In samples 16 and 17, however, which were procured with the express object of ascertaining the immediate effect of the fresh sewage of Newark (so far as might be), the figures mount up to something appreciable. In No. 16, which was taken just before the turn of the tide, at ebb, the amount of urea indicated is one part in 500,000. The amount of average *urine* itself indicated here is about three and one-half grains per gallon. It would appear, from the experience of many analysts, that during the warm season urea is so changeable and evanescent a thing, in river water, that it must be caught immediately, to be detected; and it is, therefore, probable that the amount of urine above estimated, 3½ grains per gallon, is much too low.* It must be pointed out, also, that in the low tide water at the Newark Works (No. 2), the indications of urea were unmistakeable, being doubtless due to the drainage from Passaic and Rutherford Park, above.

Animal Matters.—It is now well admitted as proved, that the ammonia obtained by distilling with Wanklyn and Chapman's reagent (permanganate and caustic potash) is of animal origin, or at least from derivatives of proteine compounds, which are usually susceptible of putrefaction. It certainly furnishes us the most reliable text for putrefiable matter in water that we have up to the present time. W. & C. believed, from their experiments, that such ammonia could be considered as indicating as much as ten times its weight of proteine matters. This my own experiments furnish me strong reason to think to be (as a universal rule) an over-estimate; but I adopt their hypothesis in setting forth my results, premising that I deem it merely a hypothesis. In any case, the results have high value, if only as comparative, and not absolutely positive. It will be observed that the amount of this "albuminoid ammonia," as it is called in the books, in the tide just after the turn from ebb to flow in Newark, August 20, was nearly three-tenths of a grain to the gallon, indicating, according to the hypothesis, nearly three grains of albuminous matter, or say twelve grains of rotten egg to the gallon, from Newark sewage. This would be equal to one rotten egg in 66 gallons—instead

* A solution of urea in water decomposes spontaneously into carbonate of ammonia, which is very volatile and escapes quickly. One equivalent of urea and four equivalents of water are resolvable exactly into two equivalents of neutral carbonate of ammonia. Presence of animal matters, acting as ferment, rapidly produces this change, and probably it is quicker also in the presence of basic carbonates.

of 200 gallons, as estimated in my report of March last; without having then made actual analyses of the water in Newark. It will also be observed (on referring to No. 3), that when the up-tide flow reaches the Jersey City Works the proportion has fallen to just one-tenth of this amount, and when the tide has risen to the Newark Works, one mile more, there is *none* appreciable. [It must be recollected, however, that there is here an element of uncertainty, inasmuch as the Newark city sample referred to was taken at a different season from the others].

Again, going down stream, it will be observed that the falling tide carries with it from the towns above, to the Newark Works, nearly one grain of this class of compounds, which, while flowing along the mile reach to the Jersey City Works through and over beds of weeds, dwindles down to little over one-tenth grain. It must be remarked also that this part of the stream absolutely *swarms* with *fish*, which of course devour all animal matter in the water that is amenable to their digestion.

Unfortunately, however, there is evidence, even in this brief table of analyses, that all these influences, the atmospheric oxidation, the plant-digestion and the fish-digestion, acting together, cannot be relied on at all seasons and under all circumstances—or, it may be, at all hours of the day, and, especially, *the night*—to remove the whole of these dangerous putrefiable substances. Nos. 10 and 11, but particularly the latter, show this without the possibility of doubt. These two samples represent average water (high and low tide mixed) pumped up at the Jersey City Works, in two very different conditions of the river, one during drought and the other during flood. The sample of August 9 indicates an amount of "albuminoid" ammonia which I much regret to see, as it suggests that, under still more unfavorable conditions, which doubtless often exist (this having been a mere random hit), the proportion that gets into the reservoirs may be far larger.

The large proportion of "albuminoid"—(0·875), brought down to the Newark works by the down flow—(No. 2), indicates the probability that, at points further up stream, still more would be found, and therefore appears to tell strongly against the somewhat hasty suggestion thrown out in my report of March last, to bring the water by canals to the pumping stations, from points higher up stream, in order to get further away from the Newark sewers. We should thus be only getting nearer to the sewers that come in above. It

must be remembered that the volume of the mean velocity of the down-flow must always be greater than that of the up-flow, and this is particularly so in times of flood. One result of these analyses must then be the definite abandonment on my part of the recommendation to take the water from higher up the river.*

I would suggest, indeed, to your Honorable Commission, that the original location of your two pumping stations just where they are, was, in some sort, a providential circumstance. They *now* lie, however, in a critical location between Scylla and Charybdis, and must, I should think, before long, be swallowed up (metaphorically speaking) by the one or the other of these monsters.

The Chlorine and Common Salt.—These ingredients are regarded by many, as furnishing ordinarily more reliable evidence than any others, of previous contamination of water by sewage. As the evidence from nitrates fails us, in a measure, during the summer season, at least, as a *comparative* test, I turn with much interest to the study of the chlorine determinations. They present points of value, and concur generally very well with the results of the Wanklyn and Chapman method; but unfortunately, in this part of the river, there is so much uncertainty with regard to possible admixture with the salt water that comes up to, or even above, Newark at extreme high tide, that I do not feel much confidence in these chlorine figures. The sample of high tide in Newark (No. 12), was procured partly with a view to determine the amount of salt water that makes its way up to Newark at high tides. The result was, that *this* high water at Newark was *exactly two thirds ocean water*. [I would call attention, also, to the curious fact that the amount of nitric acid in No. 12 is identical with that in the ocean water No. 13, the two being the poorest in this ingredient in the whole list, except No. 17. The animal matter in No. 12 (columns 9 and 10), doubtless comes from Newark sewage, which would accumulate in the water at flood, as at ebb.]

The chlorine test will be found of far more importance when we come to consider the waters of the upper water-shed, above the falls.

Further Observations on the Lower Passaic.—A few further remarks will be made, arising out of the examination before spoken of, on July 23d, from Newark up to Passaic. I was struck with the

* This suggestion has been taken up, as I observe (without credit), and made much of, by writers in the public press.

filthy appearance of the water in the town of Passaic, and the large amount of effete dye-stuffs there cast into the river. Proceeding down the river from this town, it was found that the stream was actually blackened, and the stain continued apparent for more than a mile. It was also observed that, even below the point at which the coloring matter had apparently precipitated, and the stream had become clear, the water had a distinct smell and taste of gas-tar, and films of tar were even occasionally seen floating thereon. This contamination must also have come from one or the other, or both of the towns above. The point where this taste was last observed was but a short way north of the viaduct of the Boonton branch of the Delaware, Lackawanna and Western Railroad. I may here add that films of gas-tar were observed by me on the water at the Jersey City Water Works in October of last year, but whether from Newark or from the up-river towns I could not say.

To be continued.

THE METALLURGY OF THE FUTURE.

An Address delivered before the Society of Civil Engineers of France on the 9th of January, 1874, *by their President*, M. JORDAN.

[Translated from the "Revue Industrielle."]

Since it is to you, my colleagues, that I owe the privilege of speaking here to-day, I trust you will permit me to ask your attention to the special branch of our profession to which I have devoted my energies, and, while attempting to bring before you some ideas upon what I shall call the metallurgy of the future, to show you what a fruitful field of study the iron industry can furnish, not only to those of our number who are connected actively with metallurgical operations, and have consequently at their command every opportunity for observation and experiment, but also to our Parisian brethren, who, though confined to researches more theoretical in their character, may yet be willing to consecrate to their investigation a portion of their time. I hope you will prove how easy it is to enrich our journals with original papers of great interest, and at the same time to render a service to a most important industry.

My purpose on this occasion, however, is not to occupy the time with a statement of the part which chemical science at present plays in the progress of metallurgy; a part certain to be largely increased in importance. Nor would I, even if I could, lessen this importance

in the least. But it is of course desirable for us not to confine ourselves too entirely to a study of the purely chemical questions involved; for chemistry alone will certainly not be able to reach the solution of many problems which are even now actually occupying the attention of metallurgists. To solve these questions physical and mechanical knowledge is also necessary; and it is rather in this direction than in the other that I desire to lead your thoughts for the hour.

We all, probably, have observed the significant fact, that the more the metallurgical arts progress—and we have witnessed during the past few years some marvellous advances—the more the science of heat becomes of importance in their operations. Indeed, we might almost say that the metallurgy of the future consists in largest measure in the development of this science. So that for him who will thus develop it, who will produce and control high temperatures, there seems to be in abundance both honor and profit. Even now we see about us many efforts in this direction. A never-ceasing duel is being fought between fire, whose most violent energies are roused for the combat, on the one side, and the refractory material which is to contain and to control it, upon the other. This duel recalls forcibly another contest also waged in the metallurgical arena—because in fact it is the industrial art which is really involved, not the military art—the strife between artillery and plating, between large guns and iron-clads. To construct large guns, to make them support the colossal interior pressures which correspond to the great initial velocities obtained, and which give to heavy projectiles the enormous *vis viva* which shall crush in the sides of the heaviest iron-clad before their terrible impact, taxes the profoundest resources of the metallurgist and the mechanical engineer. To manufacture plates, on the other hand, thirty, forty or even fifty centimetres thick, designed to sustain without yielding these frightful blows, to resist them without being either penetrated or even fissured, demands the most advanced skill in the iron master and at the rolls. In this Homeric duel, which has already taken on so many phases, the superiority at present is on the side of the attack. The projectile has finally triumphed over the armor. It now seems as if the result would be the same in the case of the other duel, between fire and refractory material.

Moreover—to return from our digression—how immensely inferior are the temperatures which we are actually able to obtain, to the fantastic figures which we so often have from the mouths or pens of en-

thusiastic inventors. Many practical men, even, are singularly in error in regard to the means in their possession for developing high temperatures. This is a subject which has not yet been sufficiently studied, in my opinion, in the light of modern science; or, if studied, the results have not been widely enough disseminated. I ask your permission, therefore, to point out the way in which, as it seems to me, we should study this question; and, as a preliminary thereto, to give a rapid resumé of the present condition of it in actual practice.

The great majority of metallurgical appliances where heat is generated and utilized, belong to two great classes—blast, or high furnaces, and air, or reverberatory furnaces. The former class, including both high and low blast furnaces, are among the oldest metallurgical appliances known; iron, lead, copper and tin were at one time produced exclusively in blast furnaces. Now, however, the reverberatory furnace has dethroned the low hearth and the low blast furnace, for the refining of cast iron, as it has for the manufacture of copper. Recently, in the invention of the Bessemer process, the blast furnace has seemed to take its revenge; but very soon after, thanks to the genius of Siemens, the reverberatory furnace regained the lost ground in siderurgic manufacture. And now, as a matter of fact, the Bessemer converter, fed with compressed air, and the Siemens-Martin reverberatory furnace, heated by gas and using the natural draft, divide between them, or rather yield to each other mutual assistance in, the modern industry of steel. These two methods may be regarded as the two types to which we may refer all the possible means of obtaining high temperatures, whether now known to us or hereafter to be discovered.

The more we examine the remarkable invention of Bessemer, the more we are struck with the manner in which it sprang fully armed, so to speak, from the head of its fortunate inventor. From the time of the reading, in 1856, at the Cheltenham meeting of the British Association, of the celebrated paper bearing the title "On the Manufacture of Steel and Iron Without Fuel," an entirely novel idea took possession of the metallurgical world; an idea, too, destined to be still more fruitful in results in the near future. The heating of the metal in the converter is effected without the aid of any foreign combustible substance, solely by the intermolecular combustion of the constituents of the cast iron; this combustion being effected under a pressure considerably superior to that of the atmosphere. In this way, the utilization of the heat thus produced within the metal itself

is direct and immediate. Most of it is actually absorbed by the metal, leaving but a small residue to be taken up by the walls of the converter.

The system of heating made use of by the Siemens brothers, in their furnaces, is entirely different. Here the heating is effected by means of combustible gases, produced by the distillation and imperfect combustion of coal. Their reverberatory furnaces possess two heaters, one at each end, each consisting of a sort of elongated rectangular burner, with two parallel openings, one for air the other for the gas. Both the entering air and gas are separately heated to a very high temperature. When they meet, under a pressure about that of the atmosphere, they combine and yield a powerful flame, which traverses first the furnace, where it heats the metal, and then passes through chambers filled with loosely laid fire-bricks, called regenerators. Here it gives up a large part of its remaining heat, which is to be utilized a few minutes later, in the next stage of the process, in heating the entering air and gas before their combustion. The metal forms a not very thick layer on the bed of the furnace, and is heated only by the superficial contact of the current of burning gas, and by reflection and radiation from the furnace walls, these latter being heated in advance of the metal, so that it becomes necessary frequently to cool them by artificial means (either a current of air or water) to enable them to stand the heat. The temperature of the metal on the Siemens hearth is lower than that in the Bessemer converter.

The temperature which may be obtained in a gas furnace on the Siemens system, or in the furnaces of other and more or less analogous systems which have appeared within the past few years, cannot exceed a certain maximum, which I have made some attempts to determine. The researches of Deville and Debray have proved that when we bring together, in the proportions to form water, the two gases oxygen and hydrogen, at the ordinary atmospheric pressure, all necessary precautions being taken that no part of the heat produced be absorbed by the surrounding materials, but that it be entirely confined within the products of combustion, the actual maximum temperature which is obtainable is only 2500° C., in place of 6903°, which Peclet had deduced from calculation. This discrepancy in the theoretical and experimental results is easily explained, if we remember that only one-half of the hydrogen enters into combination at 2500° under the ordinary atmospheric pressure, the vapor of the water produced having at this temperature a tendency to decompose precisely

equivalent to the affinity which, at this temperature, oxygen and hydrogen have for each other. Or, in more scientific language, at 2500° the tension of dissociation of the vapor of water is equal to the atmospheric pressure. Whatever, then, be the initial temperature of the two gases when they are mixed, we can never obtain by their combination a temperature of combustion superior to 2500° (or 2800° according to Bunsen). If the oxygen be mixed with an inert gas like nitrogen, the relative proportion of hydrogen actually entering into combination may be increased, but the actual temperature of combustion cannot be raised above this limit. But if the combustion be effected at higher pressures, at two, three, or even more atmospheres, experiment shows that the quantity of gas entering into combination goes on increasing, and that the temperature of combustion increases in the direct ratio of the pressure. Under the ordinary pressure of the atmosphere, however, the fact remains that the maximum temperature which can be produced by the combustion of pure hydrogen, a maximum impossible to attain in practice, is only about 2500° C.

The temperature of total combustion for carbonic oxide and oxygen, as determined by calculation, is 7059°, according to Peclet. But the tension of dissociation of the carbonic acid produced is considerable even at 1200°, according to Deville. Hence, although the temperature at which this tension is equal to the atmospheric pressure, that is, the temperature at which carbonic oxide and oxygen can no longer combine, has not, so far as I know, been experimentally determined; it must be certainly very far below 7000°, and probably even below 3500°.

The presence of nitrogen, when the combustion is produced by means of air, diminishes still more the temperature obtainable. Consequently, notwithstanding the great respect in which I hold the name of Faraday, I am constrained to doubt if it be possible, as Siemens tells us he said, in 1862, it would be, to obtain a temperature of 3850° C. in a furnace heated by the combustion, effected by means of air and at the ordinary pressure, of a gas containing itself more than two-thirds of inert material.

Moreover, it is necessary also to remark that in the Siemens furnace the metallic bath absorbs only a small proportion—15 to 20 per cent.—of the heat produced by the combustion; the rest being expended upon the furnace itself, in heating its walls and its regenerators, and in loss by the stack. Obviously, a flame, the weight and calorific

capacity of which are so feeble, and which is in contact with a surface of brick so much more extended than that of the molten metal, cannot furnish rapidly enough a sufficient number of heat units to raise the temperature of the furnace and the metallic bath up to that which it itself possesses, especially when the loss by conduction is taken into the account.

According to a Belgian engineer, M. Kranz, who has analyzed the working of the Siemens furnace with great care, the mean temperature of the flame on its entrance into the furnace is 3023°, that of the interior of the furnace itself being 1800°. But he does not take into the account the dissociation of the carbonic acid produced, which at this temperature must be very considerable.

It is no doubt very difficult to measure in degrees the highest temperature which can be obtained in the Siemens furnaces which are employed for melting low steel, though their inventor has undertaken to do this by means of his electric pyrometer. I believe, however, that I risk nothing in asserting that the figures of Kranz above given may be considered as a maximum.

In the Bessemer converter, owing to the small size of the opening by which the gases escape, the interior pressure is always very considerable, sometimes exceeding even by one-half the atmospheric pressure. Moreover, the carbon of the iron is burned only to carbonic oxide, which dissociates much less easily at high temperatures than carbonic acid. The silica, too, resulting from the combustion of the silicon, does not decompose at all, but remains in the liquid state in contact with the metal. For all these reasons the temperature obtained in the converter is superior to that obtained in the Siemens furnace; this temperature may be safely estimated as 3500°.

Mr. Bessemer himself understands fully the importance of effecting the combustion under a high pressure. In realization of this idea, he has quite lately, in 1869, invented a special apparatus for the purpose, a sort of hermetically closed converter, into which he blows air under a pressure of two to two and one-half atmospheres, and out of which the gaseous products of combustion issue through a very small opening, the size of which can be adjusted at pleasure. In this way he has succeeded in melting the softest iron easily, and with only a small quantity of fuel. But the direct contact of the carbon has prevented him from obtaining the melted metal sufficiently soft, a slight amount of carburization always taking place. For this reason Bessemer has abandoned this first apparatus for another, in which

the combustible does not come in contact with the melted metal. It is a sort of hermetically sealed reverberatory furnace. I am not aware in what condition these experiments are at present, nor do I know of what materials these high-pressure furnaces are constructed. But I see in all this a new proof of the originality of mind of this distinguished inventor.

What has thus far been said will be sufficient, I trust, to justify now the enunciation of the following propositions, which embody, as I conceive, the conditions necessary for the production of temperatures still more elevated than those which are at present actually in use. These propositions are:

1st. The combustible which is selected to be used as fuel must be capable of being burned within the molten metal without injury to the properties of this metal, and must yield on combustion a non-volatile product.

2d. An arrangement of furnace must be devised, heated by gas or otherwise, in which practical operations can be carried on under a pressure of several atmospheres.

It is impossible for us at present to foresee the changes which would be effected in metallurgical processes and results by the employment of temperatures more elevated than those we now actually make use of. A distinguished English physicist, J. Norman Lockyer, in a communication read to the Institute, the other day, by M. Dumas, states that during his spectroscopic investigations he has recognized the important fact, that in those stars which are hottest, only pure hydrogen is to be detected; that in those which are less hot, the metals make their appearance; in still others, yet lower in temperature, the metalloids appear; while, finally, here upon our earth, which is only an extinct star, hydrogen no longer exists free, and but a few metals and metalloids are found in this condition; while we do find an immense number of compounds of all degrees and kinds of complexity. It is easy to see from this statement of Mr. Lockyer that he considers hydrogen gas to be the ultimate limit of all dissociation; to be what Balzac, in a recent and well-known novel, calls the "absolute," and what others have called "cosmic matter." Hence he must believe that all bodies are simply metamorphoses or transformations of hydrogen, due to variable circumstances of pressure, temperature and electric state. It is hardly probable, however, that we shall ever see the number of our elements reduced to one. But shall we ever be able to carry dissociation to a degree sufficient to separate even recognized

elements from each other? to dissociate, for example, iron and oxygen, or iron and phosphorus? It must be confessed that nothing that we know as yet permits us to hope for it. But, precisely as the Bessemer and Siemens-Martin methods have given us cast steel in enormous masses, so methods may be devised, still more energetic, which shall enable us to obtain this and other metals in molecular states which are now unknown. Let me detain you a few moments upon this point.

To be continued.

ON THE STRENGTH, ELASTICITY, DUCTILITY AND RESILIENCE OF MATERIALS OF MACHINE CONSTRUCTION,

And on Various Hitherto Unobserved Phenomena, Noticed during Experimental Researches with a New Testing Machine, fitted with an Autographic Registry.

By Prof. R. H. Thurston.

(Continued from page 293.)

8.—Low Steels.—In Plate II, and above the curves just described, are a set obtained during experiments on "low steels," produced by the Bessemer and Siemens-Martin processes. In general character, the curves are seen to resemble those of the standard irons, as illustrated by Nos. 1 and 6. The irons contain usually barely a trace of carbon. These steels contain from one-half to five-eighths of one per cent. The irons are made by a process which leaves them more or less injured by the presence of impurities, from which the utmost care can seldom free them. The steels are made from metal which has been molten and cast, a process which allows a far more complete separation of slag and oxides. The low steels, however, are liable to an objectionable amount of porosity, due to the liberation of gas while the molten mass is solidifying, whenever the spiegeleisen, employed as a conveyor of carbon, is not very rich in manganese. The results of these differences in constitution and treatment are readily seen by inspecting the curves. They show a stiffness equal to No. 6, and about the same degree of internal strain. They contain a sufficient number of the capillary channels, produced by drawing down the pores while working the ingot into bar, to cause a lack of homogeneousness in structure, very similar to that produced in iron by cinder. They have a much higher elastic limit, and greater strength, and the softer grades have great ductility. In resilience, these softest steels excel all other metals, except the unusual example, No. 22, and are

evidently the best materials that are now obtainable for all uses where a tough, strong, ductile metal is needed to sustain safely heavy shocks. A comparison of the diagrams of two competing metals may thus be made to indicate how far a difference in price should act as a bar to the use of the costlier one. For many purposes, a metal having double the resilience of another is worth more than double-price. For general purposes, a comparison of the resilience of the metals within the elastic limit is of supreme importance. No. 6 is seen to have more resilience within this limit than No. 1, and the steels far more than either; but No. 1 would take a set of considerable amount far within the true elastic limit, as indicated at *a*. The most valuable measure is obtained by determining the area intercepted between the "elastic line" and the perpendicular let fall from its upper end; this measures the resilience of elastic resistance, which is the really important quality.

No. 98 was cut from the head of an English Bessemer rail made from unmixed Cumberland ores. It contains nearly 0·4 per cent. carbon. It is quite homogeneous, has a limit of elasticity at 88 foot-pounds of torsional, or 26,400 pounds per square inch tensile stress, approaches its maximum of resistance rapidly, and, at 210°, the torsional moment becomes 225 foot-pounds, equivalent to 67,500 pounds per square inch tensile stress. It only breaks after a torsion of 283°, and with an ultimate elongation of 80 per cent., equivalent to a reduction of cross section to 0·556.

No. 76 is a Siemens-Martin steel made from mixed Lake Superior and Iron Mountain ores, and contained about the same amount of carbon as the preceding. It contains rather more phosphorus, which probably gives it its somewhat greater hardness, its higher limit of elasticity and its somewhat reduced ductility. Its elastic limit is found at 104 foot-pounds of torsion, or 31,200 pounds tensile resistance, and its ultimate strength is almost precisely that of the preceding specimen. Its elongation is 0·66 maximum. Unless more seriously affected by extreme cold than No. 98, it would be preferred for rails, and, perhaps, for most purposes.

No. 67 is a somewhat "higher" steel, made by the same process. It is less homogeneous than the two just examined, has greater strength and a higher elastic limit, but less ductility. Its resilience is very nearly the same as that of Nos. 98 and 76. The elasticity of all of these steels seems very exactly the same. The ductility of No. 67 is measured by 0·40 elongation. At *d*, is seen another illustration

of elevation of the elastic limit. The piece was left twenty-four hours under maximum stress. The torsional force was then removed entirely. On renewing it, as is seen, the resistance of the specimen was found increased in a marked degree.

No. 69 is an American Bessemer steel, containing not far from 0·5 per cent. carbon. The same effect is seen here that was before noted, an increase of hardness, a higher elastic limit, and greater strength, obtained, however, by some sacrifice of both ductility and resilience. The elastic limit is approached at 130 foot-pounds of torsional moment, or 39,000 pounds tensile, and the maximum is 280 foot-pounds of moment and 84,000 pounds tensile resistance at 133°. Its maximum angle of torsion is 150°, its elongation 0·24.

No. 85 is a singular illustration of the effects of what is probably a peculiar modification of internal strain. It seems to have no characteristics in common with any other metal examined. Its diagram would seem to show a perfect homogeneousness as to strain, and a remarkable deficiency of homogeneity in structure. It begins to exhibit the indications of an elastic limit at *a*, under a torsional moment of 110 foot-pounds, or an apparent tensile stress of 33,000 pounds per square inch, and then rises at once by a beautifully regular curve, to very nearly its maximum at 16°, and 176 foot-pounds. The maximum is finally reached at 130°, and thence the line slowly falls until fracture takes place at 195°. The maximum resistance seems* to be very exactly 60,000 pounds to the square inch. Its maximum elongation for exterior fibres is about 0·23. The resilience taken at the elastic limit is far higher than with common iron, and it is seen that this metal, in many respects, may compete with steel. Its elasticity is seen to remain constant wherever taken. This singular specimen was a piece of "cold rolled" iron. It is probably really far from homogeneous as to strain, but its artificially produced strains are symmetrically distributed about its axis, and being rendered perfectly uniform throughout each of the concentric cylinders into which it may be conceived to be divided, the effect, so far as this test, or so far as its application as shafting, for example, is concerned, is that of perfect homogeneousness. The apparently great deficiency of homogeneousness in structure is readily explained by an examination of the pieces after fracture; they are fibrous, and have a grain as thread-

* With an exceptional case, of which this is an example, the scale for tension is incorrect. The tensile strength is probably higher than here given.

like as oak; their condition is precisely what is shown by the diagram, and the metal itself is as anomalous as its curve.

8.—Tool Steels.—The "tool steels" differ chemically from the "low steels" in containing a higher percentage of carbon, and usually, in being very nearly, if not absolutely, free from all injurious elements. They are made in crucibles by melting down the blister steels which are the crude product of the process of cementation, or sometimes, by melting a charge composed of selected iron, a small proportion of manganese bearing alloy and the proper amount of carbon. Containing a higher proportion of carbon than the preceding class of metals, it is comparatively easy to secure homogeneousness by the introduction of manganese, and by the same means, to eliminate very perfectly the evil effects of any small proportion of sulphur that may be present. Their comparatively large admixture of carbon makes them harder, and reduces their ductility, and since the reduction of ductility occurs to a greater degree than the increase of strength, the effect is also to reduce their resilience. The working of these metals is more thorough than is that of the less valuable steels, or of iron. They are cast in comparatively small ingots, and are frequently drawn down under the hammer, instead of in the rolls, and are thus more completely freed from that form of irregularity in structure noticed so invariably in steels otherwise treated. The effect of increasing the proportion of carbon, is to confer upon iron the property of hardening, when heated to a high temperature, and suddenly cooling, and the invaluable property of "taking a temper," *i. e.*, of assuming, under proper treatment, any desired degree of hardness. The hard steels are, however, comparatively brittle, the hardening being secured at the expense of ductility. The effect produced upon the tenacity of unhardened steel, by increasing proportions of carbon, is somewhat variable, since it is influenced greatly by the presence of other elements. For good steels unhardened, the writer has been accustomed to estimate tenacity by the following formula, which is approximately accurate, and may be often found useful:

$$T = 60{,}000 + 70{,}000\ C.$$

in which T represents the tenacity in pounds per square inch, and C is the percentage of carbon contained in the metal. This subject will be considered at greater length after a series of experiments have been made to obtain more exact determinations.

Referring to Plate II, a set of diagrams will be found, having their origin at 180°, which are *fac similes* of those automatically produced during experiments upon various kinds of tool steels.

No. 58 is an English metal, known in the market as "German crucible steel." It is remarkable as having a condition of internal strain which has distorted its diagram to such an extent as to completely hide the usual indication of the elastic limit. A careful inspection shows what may be taken for this point at about 14½° of torsion, when the twisting moment was about 120 foot-pounds, and the tensile resistance 36,000 pounds per square inch. The metal is homogeneous in structure, has an ultimate resistance of 302 foot-pounds of moment, or 90,600 pounds per square inch tensile resistance. Its resilience is evidently inferior to that of the softer metals, and also less than the next higher and better grades. This metal contains about 0·60 to 0·65 per cent. carbon. Its elongation amounts to 0·045.

No. 53 is an English "double shear steel," of evidently very excellent structure, but less strong and less resilient than the preceding. Its exterior fibres are drawn out three per cent.

Nos. 41 and 61 are two specimens of one of the best English tool steels in our market. The first was tested as cut from the bar, but the second was carefully annealed before the experiment. In this instance, annealing has caused a slight loss of resilience as well as a decided loss of strength. In No. 41, the limit of elasticity can hardly be detected, but seems to be at about the same point as in No. 61, at near 130 foot-pounds moment and 39,000 pounds tension. The ultimate strength is nearly 119,000 pounds per square inch. The proportion of carbon is very closely 1 per cent. Its section would reduce by tension, 0·05.

No. 70 is an American "spring steel," rather hard, but as shown by its considerable resilience, of excellent quality, resembling remarkably the tool steel No. 41. It differs from the latter, apparently by its much higher elastic limit. It is possible that this may have been caused by more rapidly cooling after leaving the rolls in which it was last worked. It is evident that, for exact comparison, all specimens should be either equally well annealed or should be tempered in a precisely similar manner, and to the same degree.

Nos. 71 and 82 are American tool steels, containing about 1·15 of carbon. The former is notable as having an elastic limit at 69,000 pounds, and a probable deficiency of manganese, producing the usual indication of heterogeneous structure. Both of these steels lack resilience, and are less well adapted for tools like cold chisels, rock drills, and others which are subjected to blows, than for machine tools.

They have a maximum elongation, respectively, of but 0·013 and 0·03.

Interesting and instructive as the study of these curves may be made, the information obtained from them is supplemented, in a most valuable manner, by that obtained by the inspection of the fractured specimens, upon which the peculiar action of a torsional strain has produced an effect in revealing the structure and quality of the metal that could be obtained in no other way.

Fig. 8 represents the appearance of No. 68, and Fig. 9 that of No.

Fig. 8.

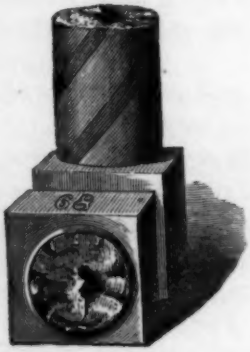
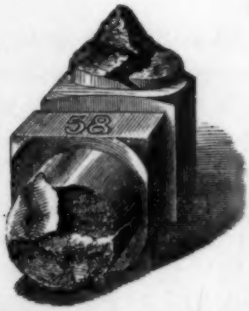


Fig. 9.



58, while the peculiarities of the finest tool steels are seen in No. 71, as shown in Fig. 10. The smooth exterior of No. 68, which is a companion specimen to that giving diagram 69, and its bright and characteristic fracture, resembling that of No. 22 somewhat, together indicate its nature perfectly, the first feature proving its strength and uniformity of structure, and the second showing, even to the inexperienced eye, its toughness. This is a representative specimen of low steels. No. 58 is seen to have retained, even more than No. 68, its original smoothly polished surface. Its fracture is less waxy, and much more irregular and sharply angular. The crack running down the side of the neck shows its relationship to the shear steels which much oftener exhibit this effect of strain, in consequence of their lamellar character. No. 58 is evidently intermediate in its character between

Fig. 10.

the soft steels, like No. 68, and the tools steels which are represented by No. 71, Fig 10. In this test-piece, the fracture is ragged and splintery, and the separated surfaces have a beautifully fine, even grain, which proves the excellence of the material. The surface which was turned and polished in bringing the metal to size remains as perfect as before the specimen was broken. By an inspection of the broken test-pieces in this manner, the grade of the steel, and such properties also as are not revealed by an examination of the diagram of strain, are very exactly ascertained by a novice, and to the practical eye, the slightest possible variations are readily distinguishable.

9. CAST-IRON.—The diagrams of strain having their commencement at 100°, have been obtained from cast-iron and from malleableized cast-iron.

Nos. 23 and 24 are those given by a good dark grey foundry iron from Pennsylvania. No. 25 represents the curve of light grey scrap, and 30 is from a very fine white Lake Superior charcoal iron. The latter is seen to be exceedingly hard and rigid, the resistance of the piece rising very precisely in proportion to the angle of torsion until it snaps at last under a moment of over 200 foot-pounds, equivalent to a tension of 60,000 pounds per square inch, and with a maximum elongation of one-tenth of one per cent. This is a most extraordinary resistance, but it is evident that, notwithstanding its immense strength, this material would be valueless for ordinary purposes in consequence of its excessive brittleness. When the torsional effort had reached about one-half its maximum amount the piece was released. The pencil retreated along a nearly vertical line *e*, which it again traversed as the strain was gradually renewed. Here as in many other cases, where a similar experiment was made, evidence is given of the truth of the statement originally made by Hodgkinson,* that every load produces a set. As will be shown, subsequently, however, it is not true in perfectly homogeneous bodies free from strain, and within their elastic limit. The light grey iron has a limit of elasticity at near one-half the maximum reached by the white iron, without any sign of reaching the limit of its elasticity. The grey has more ductility than the white iron, but has only about two-thirds the resilience of the latter. The dark grey irons are evidently better than either of the lighter grades, except in power of carrying an absolutely static load. The actual stretch of the outer surface particles

* Reports of British Association; also Civil Engineer and Architects Journal.

is very nearly the same in all three. They are excellent specimens of their class, and considerably better than ordinary irons.

No. 37 is a "malleableized cast-iron," made from the extraordinary metal illustrated in No. 30. The process of malleableizing consists in decarbonization by heating the casting made from good white iron, in contact with iron oxide or other decarbonizing material. Without removing any other constituent than the carbon, it produces a crude steel or an impure wrought-iron. When performed in the usual manner, melting the cast-iron in a cupola in contact with the fuel, and with some flux, and then carrying the process of malleableizing to the usual extent, a metal is obtained such as is illustrated by the diagram marked 37. It retains the strength of the cast-iron, and acquires some ductility.

No. 30 yielded 7° before fracture, while No. 37, vastly more ductile and resilient, only broke after a torsion of 39°, and a maximum elongation of 2 per cent. Taking the precaution to melt the iron in an "air furnace"—a form of "reverberatory"—and conducting the process of malleableizing more carefully, a still more valuable material was obtained.

Fig. 11.

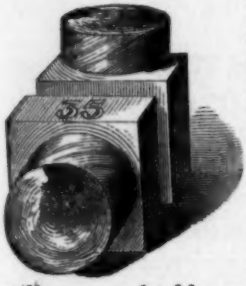
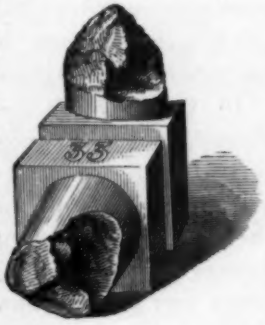


Fig. 12.



No. 35 represents this iron. Its resemblance to wrought-iron, both in appearance of fracture and in its strength and ductility, are greatly increased. It has a high limit of elasticity—over 20,000 lbs. per square inch—and such ductility that it only breaks after a torsion of nearly 168°, and an elongation of "fibre" of 0·35. It is not very homogeneous, but it is as strong, and almost as tough, as a good wrought-iron. This material has

Fig. 13.

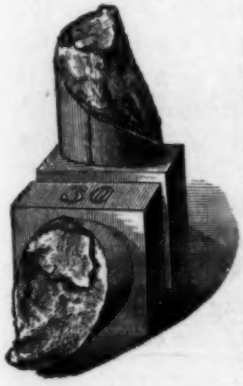
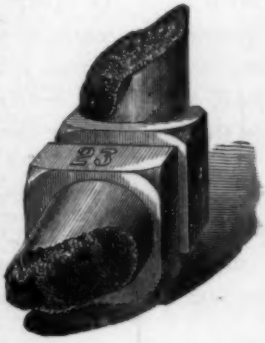


Fig 14.



especial value for many purposes, because of the facility with which awkwardly shaped pieces can be made of it. In many cases, it will prove as good as wrought-iron and far cheaper.

Fig. 11 shows the appearance of this last specimen. Its resemblance to wrought-iron is very noticeable. The lines running like the thread of a screw around the exterior of the neck, and the smooth even fracture in a plane precisely perpendicular to the axis, are the instructive features. Fig 12, representing No. 33, is a specimen similar in character to No. 37. The comparative lack of ductility, its less regular structure, and its less perfect transformation are perfectly exhibited. Fig 13 is an excellent cut of the white iron as cast and without malleableizing. Its surface, where fractured, has the general appearance of broken tool steel. The color and texture of the metal are distinctive, however. It has none of the "steely grain." Fig. 14 represents the dark grey iron. Its color, its granular structure and coarse grain are markedly characteristic, and no one can fail to perceive, in the specimen, the general character which is exactly given by the autographic diagrams of the testing machine.

10. Other Metals.—The diagrams numbered 87, 88 and 89, are those of copper, tin and zinc. These specimens are all of cast metal, carefully selected under the direction of the writer, and molded and cast at the Stevens Institute of Technology. They exhibit neatly the wonderful superiority which the various kinds of iron and steel possess over the other useful metals. These metals all take a set under very small strains, pass their limits of elasticity at some indeterminable, but evidently low point, and possess very slight tenacity.

Zinc, No. 89, by the regularity of its curve shows a very uniform structure. It increases very gradually in resistance to torsion, until it reaches the angle 50°, at which point it has a moment of torsional resistance of 36 foot-pounds, and a maximum tenacity of about 10,800 pounds per square inch. It loses its power of resistance, after rupture commences, as regularly, but not as slowly, as it acquired it, and rupture becomes complete at 63°. Its resistance is exceedingly small, and it is evidently unfit to bear either static or dynamic force. Its stretching power has a maximum of 0·04.

Tin, No. 88, is equally remarkable for its exceedingly feeble resistance and its great ductility. The specimen was excellent, both in quality of metal and in closeness of structure, as was indicated by the clearness of the "tin cry" heard while undergoing the test and by the fine, smooth, clean fracture. The character of the curve is simi-

lar to that of zinc, but has far greater extent. Its elastic limit is quite indeterminable. The outline of the diagram indicates very perfect homogeneousness. The maximum resistance to torsion is found at 240°, and under a stress of 19 foot-pounds. Its tenacity deduced from the diagram is, at most, but 5,700 pounds per square inch. Rupture occurs very gradually, and the piece separated entirely at 355°. Notwithstanding its great ductility, its low tenacity produces a low resilience, although in this quality it excels zinc, which latter metal had nearly double its strength. Its elongation by tension would have reduced its section to 0·6 of the original cross area, if that reduction were proportional to the ductility shown by the diagram.

Copper, No. 87, cast in green sand, like the zinc and tin just described, was found, on examination of the fracture, to differ from them in being exceedingly porous. The effect of this fault has been to weaken it seriously. Its curve closely resembles that of zinc, but is abruptly terminated by the piece suddenly breaking off at 46°. It reaches a maximum sooner than zinc, at 29°, and its greatest resistance to torsion is 36 foot-pounds, or to tension 10,800 pounds per square inch, precisely the same as zinc. Its ductility has a value of one and a half per cent. Its resilience is somewhat less than that of zinc. Its limit of elasticity is difficult to determine, but has been taken at 1½° where the moment of resistance is 13 foot-pounds, equivalent very nearly to 3,900 pounds tenacity, per square inch.

No. 134 is the curve of cast copper, precisely similar to No. 87, but cast in a dry sand mold. The marked difference between these specimens is probably due, not only to the difference in degree of porosity which arises from the presence of vapor, which permeates the casting in one case, filling it with bubble holes, and which is almost unobservable in the last, but the slower cooling of the dry sand casting also probably produces its effect in strengthening the metal. This last specimen has a limit of elasticity at not far from 13¾°, and under a torsional stress equivalent to a tension of 5,400 pounds per square inch. The maximum values of these quantities are found at 21°, and are 42 foot pounds, and 12,600 pounds per square inch respectively. The resilience of the specimen is much greater than that of the preceding, and its maximum elongation is ·026. Altogether, this is far betterthan the preceding, and it would seem that copper, and probably all its alloys, should, when possible, be cast in dry sand, to secure density and strength.

No. 141 is a piece of forged copper, hammered into a one-inch

square bar, from a piece originally 3½ inches wide and ¾ inch thick. The most striking property noticed is its immense ductility, far exceeding that of any other piece of metal yet tested, and, in amount, many times as great as the cast metal. Its limit of elasticity is reached very quickly, although it is impossible to say precisely where it occurs. Comparing its "elastic line" with the initial portion of the curve, it is seen that the slightest force produces a set which is proportionally large as compared with the sets of other metals. The curve rises very regularly and gradually to a maximum, which is only attained, however, after a total angle of torsion of 450°, and which measures 96 foot-pounds moment, or 28,800 pounds per square inch. Rupture is finally obtained after a torsion of 543°. The maximum elongation is 210 per cent., the most elongated lines of particles being finally left of 3·1 times their original length. Had this change of form occurred by reduction of section, the fractured area would have been but ·323 the area of original section. The resilience of this piece of metal is evidently insignificant within the limit of which it would be seriously distorted by a blow, but is quite large in amount where resistance extends to the point of rupture. This is perfectly consonant with that knowledge of the material which every mechanic derives from experience with it. Here, however, we have a complete account of its properties, written out by the material itself with definite and accurate measures.

11. General Conclusions.—These plates, exhibiting the diagrams, which are the autographs of all the useful metals, illustrate sufficiently well the remarkable fullness and accuracy with which their properties may be graphically represented, and the convenience with which they may be studied, with the aid of so simple a recording machine. A comparison of results deduced as shown, with those obtained, so far as they can be obtained at all, the usual method of simply pulling the specimens asunder, and trusting to, sometimes, unskillful hands and an untrained observer, for the adjustment of weights and the registry of results, will indicate the close approximation of this method in even ascertaining the behavior of the metal in tension. On examining the beautifully plotted curves given by Knut Styffe, as representing the results of the experiments, made by him and by his colleagues, with a tensile machine, no one can fail to be struck with the similarity of those diagrams to the curves here produced automatically, and it will be readily believed that not only must there be very perfect correspondence of results where the two methods are carefully compared, but, also, that any theory of rupture must be defective

which does not apply to both cases. The equations of the curves here given and those of the curves obtained by Styffe must have forms as similar as the curves themselves.

The constant ratio here assumed between the torsional resistance and the tensile strength of the metals, and of homogeneous materials generally, is based upon a comparison of the results here given with those obtained from the irons by tensile test, by the writer, and is confirmed by a compilation of results given by other experiments on the same brands.

12. TESTING WITHIN THE LIMIT OF ELASTICITY.—In determining the value of materials of construction, it is usually more necessary to determine the position of the limit of elasticity and the behavior of the metal within that limit than to ascertain ultimate strength or, except, perhaps, for machinery, even the resilience. It is becoming well recognized by engineers who are known to stand highest in the profession, that it should be possible to test every piece of material which goes into an important structure and *to then use it* with confidence that it has been absolutely proven to be capable of carrying its load with a sufficient and known margin of safety. It has quite recently become a common practice to test rods to a limit of strain determined by specification, and to compel their rejection when found to take a considerable permanent set under that strain. The method here described allows of this practice with perfect safety. The limit of elasticity occurs within the first two or three degrees, and, as seen, the specimen may be twisted a hundred, or even sometimes two hundred times as far without even reaching its maximum of resistance, and often far more than this before actual fracture commences. It is perfectly safe, therefore, to test, for example, a bridge rod up to the elastic limit, and then to place the rod in the structure, with a certainty that its capacity for bearing strain without injury has been determined and that formerly existing internal strain has been relieved. The autographic record of the test would be filed away, and could, at any time, be produced in court and submitted as evidence—like the "indicator card" of a steam engine—should any question arise as to the liability of the builder for any subsequent accident, or as to the good faith displayed in fulfilling the terms of his contract. A special machine has been designed for this case.

13. The above will be sufficient to show the use and the value of this method. In the course of experiment upon a large number of specimens of all kinds of useful metals and of alloys, a number of interesting and instructive researches have been pursued, and some

unexpected discoveries have been made. Before taking up the theory of rupture, the construction of equations, and the determination of their constants, a section will be devoted to an account of these investigations.

BARYTA—ITS MANIFOLD USES IN THE ARTS.*

By Dr. Lewis Feuchtwanger.

The various salts of baryta have long been employed in pyrotechny; as admixture to white lead; as material almost indispensable to card makers for a permanent white; in sugar refining: in chemical operations, etc.

In nature we find but few varieties. The sulphate, composed of 66 per cent. baryta and 34 per cent. sulphuric acid, is abundant in England, France, Germany and the United States, where it most generally is found in connection with beds or veins of metallic ores, as gangue, or veinstone. Sometimes, however, it forms distinct veins, in company with secondary limestone, and very often in fine crystals, along with calcite and celestite. Crystals of large dimensions occur in Westmoreland, Cornwall, Cumberland and Derbyshire, in England. Beautiful specimens of septaria, cut and polished for table and other ornaments, having linings of brown heavy spar, are wrought in Durham, England, in Hungary, at Freiburg in Saxony, Clausthal in the Hartz, in Bohemia, and in Auvergne, France.

The localities in the United States are very numerous. The States of Connecticut and Missouri have long furnished abundant material for the arts. Next come Virginia, New York, New Hampshire, Massachusetts, Pennsylvania, Kentucky, and Tennessee. In Canada fine crystals occur, and massive baryta in a 27-foot vein. It is reported from New Mexico also.

The Bologna spar is the ornamental stone, of a brown color and concentric rings, originally found in a bed of clay near Bologna, where it formerly was considered a great curiosity, on account of its phosphorescence, displayed after heating with charcoal, and it was called the Bologna phosphorus. The common name of sulphate of baryta is heavy spar or barytes; specific gravity 4·5, and hardness 3. It is found in nature in large crystals, weighing 100 lbs. and more, and in slender needle crystals; also in massive aggregations of tab-

* A paper read before the Polytechnic Club of the American Institute, Dec. 4th, 1873. (Communicated by the author.)

ular crystals likewise columnar and radiated, and in globular and nodular concretions; also lamellar and granular, earthy and stalactitic.

The sulphate of baryta often occurs associated with lime and some silica and alum, and is then called calcareobarite; and if it is associated with strontia, it is called baryto-celestine. If the sulphate of baryta gives out a fetid odor on striking or rubbing it, it is called fetid baryta. The name of baryta is derived from the Greek language, *βαρυς*, heavy.

Witherite is a carbonate of baryta, having a specific gravity of 4·, and a hardness of 3·2, and consists of 78 per cent. of baryta and 22 per cent. of carbonic acid. This mineral is found in considerable quantities in England, at Alston Moor in Northumberland, in Silesia, Hungary, Styria, Sicily, Chili, but not much in the United States. It is extensively employed in the manufacture of plate glass and the manufacture of beet root sugar in France, and for the production of *blanc-fixe*, or permanent white; it is much used of late for paint, particularly in combination with soluble glass and white oxide of zinc.

The metallic base of the baryta salts is called barium, and is obtained from the carbonate of baryta or chloride of barium, if put in a platinum dish and connected with the positive pole of a strong galvanic battery, in order to decompose it, mercury being placed in a hollow made in the baryta and connected with the negative pole. The result is an amalgam, which may be distilled in a bent tube filled with hydrogen. Barium is a white, malleable and fusible metal, which oxidizes easily in the air and decomposes water at common temperatures. For the purpose of obtaining the pure baryta or barium oxide, the nitrate is calcined at a red heat in a silver or porcelain crucible, or the carbonate is mixed with pulverized charcoal in a covered crucible, and exposed for an hour to a strong heat. If oxygen gas is passed over it, it will absorb that gas with avidity and become a peroxide. This is the substance used at the present day for production of the peroxide of hydrogen, which is much recommended as a medical reagent, and employed in the arts for bleaching animal tissue, or converting brown into blonde hair. To prepare it, the peroxide of barium is treated with hydrochloric acid, and the liquid, previously decomposed with sulphate of silver, is carefully evaporated to a syrupy consistency, when it yields a slight chlorous odor. It decomposes easily into water and oxygen, and it is therefore almost impossible to prepare it properly in hot weather. At 212 deg. F. it decomposes with violence.

The oxide of barium, or caustic baryta, unquestionably rivals in its causticity, potash, soda and ammonia, and may be easily employed in the compounds with chromic acid.

The chloride of barium is obtained by fusing the sulphate of baryta, or native heavy spar, with chloride of calcium (the residue from the preparation of ammonia), in a reverberatory furnace, and subsequently extracting with hot water, leaving the sulphate of lime undissolved.

The chlorate of baryta, which is now extensively used for producing a green flame in the manufacture of fireworks, is prepared by dissolving artificial carbonate of baryta in chloric acid solution, when it forms beautiful shining tabular crystals. It is dangerous to keep on hand when mixed with charcoal or sulphur.

Nitrate of baryta, which is likewise used in fireworks, may be easily prepared by dissolving the native carbonate in nitric acid and evaporating the solution, whereby octahedral crystals of the nitrate are deposited.

The native sulphate of baryta is generally used for the adulteration of white lead or paint, to the extent of 25 to 50 per cent. Of this mineral 4,000 tons are produced annually in Connecticut, and 2,000 tons in Missouri, while 10,000 tons are imported from England and Germany. The native mineral, if very white and free from iron coating is finely ground and floated with water. But most of the native mineral contains fine particles of iron, and hence requires a different treatment, namely, calcination for some hours, in order to oxidize the iron to a higher degree, when hot water and, if necessary, a little sulphuric acid, will take up all the iron, and a beautiful white heavy powder is deposited, which is then dried, either by steam or in the same manner as whiting is dried, in the atmosphere. White oxide of zinc, as well as white lead, may be mixed with sulphate of baryta in linseed oil to a pigment, which is then fit for in- and out-door painting, and spreads well.

The artificial sulphate, called white or *blanc fixe*, which is now largely manufactured in France, England, and the United States, is used in the manufacture of a paper of the purest white, in imitation of linen, and used for cheap collars, skirts and cards. It was formerly manufactured from the native carbonate of baryta, but is now prepared from chloride of barium, which is obtained in England as a waste product at a reduced price. This is decomposed with sulphate of ammonia, and pure sulphate of baryta is precipitated. Another process for obtaining the chloride of barium, in order to prepare the permanent white, is by the decomposition of the native

sulphate of baryta with chloride of sodium in a strong fire, and the subsequent solution of the fused mass in boiling water. The result is chloride of barium and sulphate of soda or glauber salt. About 5,000 tons of permanent white are annually manufactured in this country and Europe.

In the chemical laboratory, the barium salts are indispensable for the determination of sulphuric acid, which forms the sulphate as an insoluble precipitate. The carbonate of baryta is a strong poison to animals, and is used for killing rats, etc.

A green paint, composed of manganese and caustic baryta, under the name of manganese green, has been brought to market from abroad, but was soon superseded by the beautiful Guignet green, a composition of aniline and iodine.

The beet sugar refiners of France have very successfully employed both caustic baryta and the carbonate in their operations. They treat, first, the saccharine juice with lime and then with carbonic acid, in order to clarify it. Afterwards they add baryta in order to obtain an insoluble precipitate, a saccharate of baryta. After passing sufficient carbonic acid gas under a pressure of about half an atmosphere upon this precipitate, a separation takes place and, without any evaporation, the hot solution is left to crystallize.

In copper metallurgical operations, the sulphide of barium has latterly been employed for the purpose of precipitating from an ammoniacal copper solution the copper as a sulphide, which is treated in the usual method for reduction, either by caustic lime, or by borax, or by a galvanic current.

The artificial carbonate of baryta, obtained by passing carbonic acid gas through a sulphide of barium, whereby the carbonate of baryta is precipitated, is much used in Europe in glass making for producing an achromatic glass. In 1826, I assisted in Jena my teacher, Koebner, in experiments for this object.

The Canal across the Corinthian Isthmus.—The Greek Government has granted permission to cut a canal across the isthmus at Corinth, under the following conditions:

The canal is to be 42 meters (137 ft.) wide at top, and 3½ meters (11½ ft.) in minimum depth. In the middle of its length there is to be a dock with warehouses, covering 300,000 square meters (74 acres). The work is to be completed in six years, and the concession to the company is for ninety-nine years. The cost is estimated at 200 millions of francs.

On the Effect of Phosphorus on Steel.—At the February meeting of the French Society of Civil Engineers, M. Euverte, director of the steel works at Terrenoire, communicated some details relative to the experiments which have been in progress for the past two years at those works, in order to ascertain the point at which the presence of phosphorus in steel becomes injurious. They were led to these experiments by the difficulties they encountered in freeing the metal from this substance. The metal containing the phosphorus was treated in a Siemens-Martin furnace, in the usual way, the charge of ferro-manganese added containing 42 per cent. of manganese. Not only in the first experiment, but in all the subsequent ones, the metal obtained was malleable and of excellent quality. Hence, M. Euverte concludes that phosphorus may exist in the steel without injury, provided that the carbon be at the same time proportionately diminished. The amount of phosphorus which may be present without affecting either the tensile strength of the steel or its malleability is variable; rails of great excellence were made of steel containing 0·3 per cent. of phosphorus and 0·15 of carbon. Though not recommending the addition of phosphorus, M. Euverte believes that, for special uses, steel which contains it, provided the carbon is low, will take an important place in the arts.

A New Theory of Waterspouts.—It has been hitherto assumed that the column of air which revolves to produce a waterspout is an ascending column. M. Faye, the astronomer, has recently maintained before the French Academy the theory that the air in these columns is a descending one. Precisely as in a river, vertical layers of water, moving with different velocities, form whirlpools in shape like funnels, drawing the water away from the center, so, when currents of air above the clouds move in different directions, or in the same direction with different velocities, they produce upon their borders a gyratory motion of the interposed air. This air descends like the water in the whirlpool, and if the gyratory movement be powerful enough, the tube of rotating air may reach the earth. At the same time the centrifugal force determines the matter to the exterior, and causes a partial vacuum in the interior, thus explaining the lifting of objects over which the whirlwind passes, and in the case of water producing waterspouts. Of course the barometer in the centre experiences a sudden fall. The solar spots Faye explains in this way, supposing them to be whirlwinds seen vertically. The solar gas drawn into them being cooler, appears as the dark umbra.

Completion of an Immense Safe.—Mr. Chubb, the well-known English manufacturer of safes, has recently completed, for the Government of Buenos Ayres, an iron safe of gigantic dimensions, designed to receive the title-deeds and securities of the Department of Public Credit. It is a parallelopiped formed by plates of heavy iron, strongly riveted at the edges. Within this is a second box as solidly constructed as the first, and separated from it by an air-space. In this interior safe the valuable property is placed. The interior filling is made with a composition whose character is at present a secret, but which appears to have a certain quantity of alum in it. The dimensions of the safe are: height, eleven feet six inches; length, fourteen feet nine inches; depth, five feet. The plates are three-quarters of an inch in thickness, and at the corners the total thickness of the plates and braces is nearly five inches. Two doors, one and one-quarter inches thick, give access to the interior. They are made of steel and iron, and have compartments filled with non-conducting material. Two safety locks are attached, containing each a charge of gunpowder capable of firing fourteen projectiles in all directions. Each lock is of a different form. The safe, entire, weighed fifteen tons. It was shipped in pieces, and is to be put together at its destination by a competent mechanic, who accompanied it for that prpose.

Franklin Institute.

HALL OF THE INSTITUTE, April 15th, 1874.

The meeting came to order at the usual hour, with President Coleman Sellers in the chair.

The minutes of the previous meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting held April 8th, the following donations had been received, to wit:

Dictionary of Elevations, and Climatic Register of the United States, &c. By J. M. Tonner, M.D. From the Author.

United States Textile Manufacturers' Dictionary; comprising Woollen, Cotton, Silk, Jute, Flax and Linen Establishments. 1874. From the National Wool Manufacturers' Association of America, New York.

Transactions of the American Institute of Mining Engineers, Vol. 1. May, 1871, to Feb., 1873. From the Institute.

Report on the Swinburn Breech-loading Rifle. By J. Beverley Fenby, Esq., C. E., &c. From the Author.

Proceedings of the Academy of Natural Sciences, of Philadelphia, Part 3d. October to December, 1873. From the Academy.

Memoirs of the Geological Survey of India, Vol. 1 (No. 1), Vol. 4 (Nos. 3, 4), and Vol. 10 (Pt. 1). Calcutta. From the Superintendent.

Records of the Geological Survey of India, Vol. 6 (Pts. 1—4). 1873. Calcutta. From the Superintendent.

Annales des Ponts et Chaussées for September and October, 1873. Paris. From the Editor.

The Actuary likewise reported the following communication from the Committee on Science and the Arts, and the action of the Board thereon:

To the Board of Managers of the Franklin Institute:

GENTLEMEN,—At the stated meeting of the Committee of Science and the Arts, held March 6th, 1874, a resolution was passed, instructing me to recommend to you the award of the Scott Legacy Premium and Medal to George Westinghouse, Jr., of Pittsburgh, Pa., for his improvements in air brakes for railway trains.

Respectfully,

JOHN C. CRESSON, *Chairman Com. S. and A.*

Philadelphia, March 26, 1874.

The following is the action of the Board on the above: On motion, it was

Resolved, That, in accordance with the above recommendation, the John Scott Legacy Premium and Medal be awarded to Geo. Westinghouse, Jr., of Pittsburgh, Pa., for his improvements in air brakes for railway trains, and that the Actuary be directed to make proper publication of the same.

The Actuary further reported from the Board the following resolutions, viz.:

Resolved, That the Committee on Exhibitions be directed to secure a guarantee fund of $25,000, and thereupon publish notice of the intended Exhibition, and make proper preparations for the same.

Resolved, further, that the Committee on Exhibitions be enlarged, by appointment by the President, so as to consist of 100 members, including all the members of the Board of Managers.

On behalf of the Committee on Exhibitions, the Chairman, Mr. Wm. P. Tatham, then made the following report, viz.:

The Committee on Exhibitions respectfully report that, by virtue of a resolution of the Board of Managers, passed April 2d, 1874, it has become a joint committee of the Board and of the Institute at large, to consist, in all, of 100 members, appointed by the President of the Institute, and in this connection they recommend the adoption of the following resolution:

Resolved, That the members of the Institute furnish the President with names from which to select persons to fill up the Committee on Exhibitions to the number of one hundred.

The Committee further report that the Board of Managers having, at the same date, directed the Committee to secure a guarantee fund of not less than twenty-five thousand dollars, subscriptions have been solicited and obtained already to the amount of over thirty-five thousand dollars—the list being still open. Members desiring to subscribe will find the list with the Actuary.

The Committee further report that, the conditions required by the Institute and the Board of Managers having been fulfilled, they have issued the following notice, which they desire may be considered part of this report.

On behalf of the Committee,

W. P. TATHAM, *Chairman.*

The following notice is the one referred to:

The Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, will celebrate the fiftieth year of its foundation by an Exhibition of Arts and Manufactures, to be held in the City of Philadelphia, from the 6th to the 31st of October, 1874.

The exhibition will embrace all materials used in the Arts, in every stage of manufacture, from their natural condition to the finished product, and all tools, implements and machines, by which the gifts of nature are changed and adapted to the use, the comfort, or the enjoyment of mankind.

The Committee desire to make this Exhibition represent as fully as possible the mechanical improvements of the last half century—to which the Institute has so largely contributed—and all artisans, mechanics, manufacturers and inventors throughout the United States are cordially invited to contribute their best productions, and compete for the prizes which will be awarded to the most worthy.

Every facility will be afforded for exhibiting machines in motion. All persons desiring to exhibit are requested to make early application for floor space or steam power, or for room to exhibit boilers or engines in operation to drive the machinery of the Exhibition.

Foreign materials or manufactures, not entered for competition, will be welcomed and fairly exhibited.

Communications are to be addressed to *The Committee on Exhibitions Franklin Institute, Philadelphia, Pa.* Detailed information concerning the rules and regulations governing the Exhibition will be sent in reply.

By direction of the Committee on Exhibitions,

W. P. TATHAM, *Chairman.*

Philadelphia, April 14th, 1874.

It was, thereupon, moved that the report be accepted, and the reso-